Holograms: an Alternative Rendering Technique to Help Counter the Loss of Archaeological Materials due to the NAGPRA Laws

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Holograms: an Alternative Rendering Technique to Help Counter the Loss of Archaeological Materials due to the NAGPRA Laws

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Dedications

To my parents for their encouragement throughout my undergraduate and graduate work even though there were many frustrations and disappointments along the way to its' fruition. To Dakota for foregoing many hours of his playtime so I could work on my thesis. Thanks Mom and Dad and Dakota for seeing me through the exordium, compilation and terminus of my undergraduate and graduate education.

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"There's no such thing as objective truth. We make our own truth. There's no such thing as objective reality. We make our own reality. . . . Science itself is irrational or mystical. It's just another faith or belief system of myth, with no more justification than any other".

Theodore Schick, Jr., and Lewis Vaughn,
How to Think About Weird Things: Critical Thinking for a New Age
(Mountain View, CA: Mayfield Publishing Company, 1995)

Holograms: an Alternative Rendering Technique to Help Counter the Loss of Archaeological Materials due to the NAGPRA Laws

On November 16, 1990 the United States Congress ratified the Native American Graves and Repatriation Act (NAGPRA). This was an important step in mending the relationship between the United States Government and Native American Indians. While NAGPRA can be viewed as justly due to Native American Indians and their ancestors, it creates problems for archaeologists, anthropologists, museum curators and future students as well as removing part of the collective prehistoric and historic past of the United States. The NAGPRA laws are taking away from archaeological researchers and museum curators hundreds of thousands if not millions of artifacts including human skeletal remains of prehistoric and historic Native American Indians that had been collected, studied, stored and displayed, many times to the disapproval and dismay of living Native Americans. While NAGPRA does allow a period of time for cataloguing and photographing the artifacts, it does not address the question of whether future studies will need data that photographs, drawings, and other types of records cannot accommodate. This loss is substantial but it does not have to be a total loss to archaeological research, study and display. Besides the standard use of drawings, photographs, and other forms of record keeping, I will argue there is potential for using holography and the hologram to inventory, catalogue, display and study artifacts and skeletal remains as well as using holograms as teaching aids. Holograms would give an added dimension to the use of renderings in the study of what is no longer physically available, in this case the repatriated Native American Indian artifacts and skeletal remains.

I will talk about the NAGPRA law and its impact on archaeology. I will discuss

the use of other renderings that have been and are still used in archaeology as well as new rendering technologies. I will discuss in detailed length the use of holography as a viable alternative to other rendering techniques, included in this section is how holography works, the process of producing holograms and the problems encountered when working with holograms and the solutions to these problems. I will show the benefits of using holograms in archaeology, museums and in teaching as well as discuss at the end of this paper how renderings in general play a role in the process of acquiring knowledge and framing reality.

NAGPRA

The need for any and all types of renderings of Native American Indian artifacts was triggered by the 1990 legislation entitled NAGPRA (Native American Graves Protection and Repatriation Act).[1] This act of Congress gave back the originals of reality that we can know or that we think we can know (in an epistemological sense) in order to understand ourselves and the world we live in. NAGPRA brought to the forefront the controversy that had been festering for decades between archaeologists and museums on the one hand and Native American Indians on the other. The controversy stems from the

[1]A synopsis of NAGPRA/Public Law 101-601 and its amendments is as follows: that Native American remains and funerary objects, sacred objects and certain other cultural objects newly excavated or that have already been excavated on federal or tribal lands belong to the tribes involved if the tribe can prove ownership and if the tribe is legally recognized by the Federal Government. It also states that all federal agencies and all museums that receive federal funds are required to compile inventories and written summaries of the portions of their collections that may include Native American human remains, unassociated funerary objects, sacred objects and objects of cultural patrimony. The conditions of NAGPRA also dictated that any state or local institutions or government agency which includes any institution of higher learning receiving federal funds would also fall under NAGPRA (United States Congressional Law 1990) (see appendix 1).

conflict between the scientific desire or as some argue "right" to know and the moral and ethical issues as well as the religious, cultural and human rights of Native American Indians and their ancestors. Examples such as the incineration in the 1960s of many bones of Native Americans as well as the misplacing of many others by the University of Nebraska helps illuminate why NAGPRA was necessary. The University plans to return the remaining bones to the various claimant tribes and also plans to build a memorial to Native Americans on the area where the ashes were scattered (The Chronicle of Higher Education 1998).

It had been estimated that over 600,000 prehistoric and historic Native American human remains are housed in museums and institutions across the country (Lomawaima 1990), not to mention collections of hundreds of thousands if not millions of other cultural artifacts pertaining to Native American Indians. These types of artifacts are sacred objects of specific ceremonial and religious value and use, and objects of cultural patrimony that are of ongoing historical, traditional or cultural importance. The American Indian Ritual Object Repatriation Foundation has stated that, "The loss of ceremonial material has prevented many American Indians from passing ritual knowledge to future generations, consequently destroying traditions of prayer, medicine, and rites of passage" (WWW.repatriationfoundation.org). While this is a compelling statement by the Repatriation Foundation for the repatriation of skeletal remains and artifacts through the NAGPRA laws, many problems stem from the ambiguous, confusing and contradictory interpretations of the laws themselves including the fact that archaeologists will be forced to study renderings instead of the originals. This can have an effect on knowledge because new scientific techniques such as DNA sampling of skeletal remains would not be

allowed after repatriation.

While the Society for American Archaeology recognizes the needs of both traditional Native Americans and the scientific community, it concurs that "human skeletal materials must at all times be treated with dignity and respect". (www.saa.org.) However, it opposes the across the board and indiscriminate reburial of skeletal remains. Members fervently believe that each case of conflicting claims should be assessed separately and "…consideration of the scientific importance of the material, the cultural and religious values of the interested individuals or groups, and the strength of their relationship to the remains in question" should be used to resolve the conflicts with the scientific base being determined by the potential in aiding in present and future research (www.saa.org).

The authors of NAGPRA and its amendments recognized the value to archaeology, anthropology, and science in general of collections by including in the law a set period of time to allow holders of collections to study, inventory, photograph and compile data on each item in their collections that might have the potential of being repatriated. The time frame varies in length according to the number of artifacts and skeletal remains to be identified, but the allotted time frame to complete the inventory was set at five years after the date of enactment of the NAGPRA act. After it has been determined that a particular skeletal remain or associated funerary artifact is culturally affiliated to a specific tribe, a notice is sent out to the associated tribes to claim the items in question. There is a 30 day window during which a reply by the affiliated tribes for the return of their artifacts and skeletal remains must be made. However, extensions up to 180 days are commonly procured by those who are holding the artifacts and skeletal remains in their collections. This allows them to finish with any scientific endeavor that

includes the artifacts or skeletal remains in question. The law also allows artifacts to remain in collections and for the most part, except in some cases of sacred artifacts, they are allowed to remain on display, if it can be shown that they were obtained legally and with the consent of Native Americans.

I believe that with each new archaeological excavation, new artifacts are recovered from the past that can lead to the need to re-examine previously unearthed artifacts. The need to have a reliable and accurate representation of the artifacts is essential if not crucial for comparative study, research and theorizing. The most recent controversy that started in July 1996 and continues today (Nov. 1998) concerns the Kennewick man dated to 8400 B.P. (before the present). Discovered in the shallows of the Columbia River in Kennewick, Washington, a battle ensued over whether the Native Americans would rebury it right away or whether archaeologists would be able to keep it for scientific study. This discovery is very rare and important because of its age and the fact it had a piece of a projectile point of the Cascade phase embedded in its pelvis bone. At the center of this dispute is the assumption that there is a direct genetic and cultural continuum between living Native Americans and those who have passed away many centuries earlier such as Paleoindians. How can a lineage be established for affiliation spanning numerous generations when their history was unrecorded? As Meighan notes, " . . .Indian knowledge of the traditions of their ancestors is derived in large part from the collections and scholarship that the activists among them are now seeking to destroy" (1994: 66). These collections of artifacts and skeletal remains also include the various renderings produced at sites and in the research labs. Because many of the artifacts and skeletal remains that fall under NAGPRA's coverage are the base work on which archaeologists

build knowledge of the past, how this information is preserved through various rendering techniques is an important element of archaeology.

Renderings In Archaeology

To photograph or not to photograph, to draw or not to draw, to render or not to render: in archaeology, you must do it all. It is essential to make renderings in as many ways possible in order to obtain as much information and data as you can from an artifact or skeletal remain. Typically archaeologists use drawings, photographs, journals, maps and reports to aid them in their research. In the not too distant past, archaeologists were limited in the ways they could bring back data gleaned from artifacts, skeletal remains and architectural structures other than the artifacts themselves. If bringing back an artifact from excavations was not possible, drawings or photographs as well as detailed measurements and textual descriptions of the artifacts in question were made and these renderings then became the source for others to draw on in the search for archaeological explanations. Because it is not possible for all archaeologists who want to study artifacts or structures from remote areas of the world to actually go to these geographic locations they must rely on others' data. For example, the stelae in the jungles of South America or structures such as Machu Picchu and the pueblos or cliff dwellings of the southwestern United States are not readily accessible, both due to geographical obstacles. In order to examine how different building styles developed, archaeologists are forced to draw on renderings of these areas.

Paintings, drawings and journals played a part in documenting the Native American Indians. The noted reporter and painter George Catlin produced drawings and paintings between 1832 and 1839 during his travels among the North American Indians.

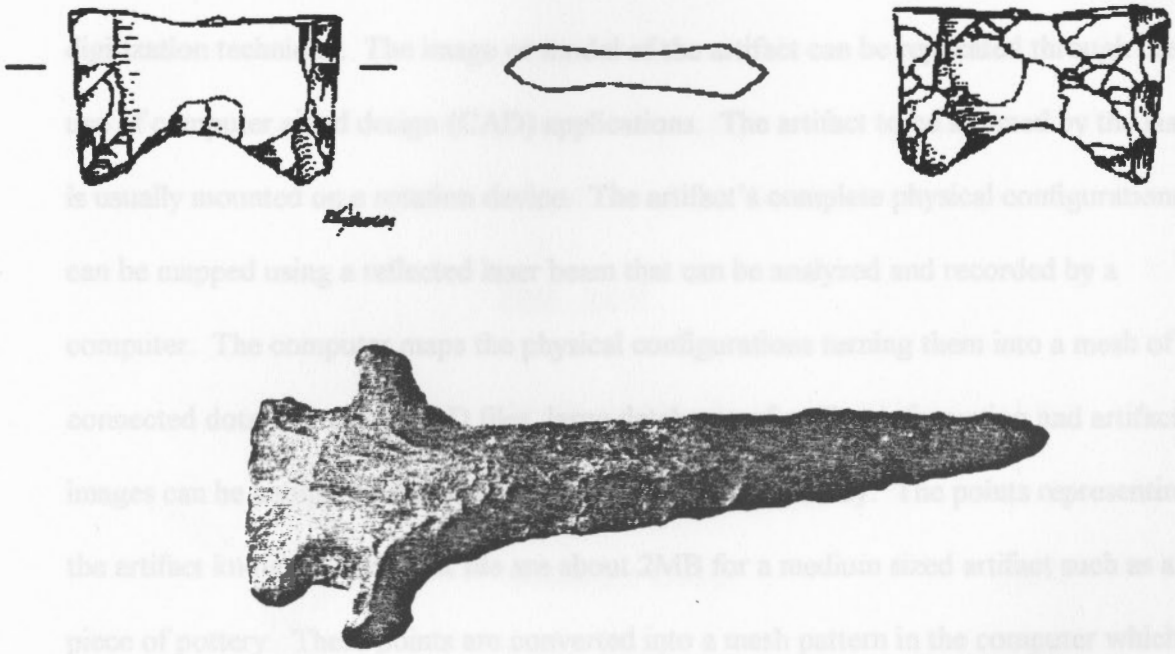
These renderings documented the manners, customs and conditions of these peoples. Even though he was methodical and meticulous, some of his renderings of geometric designs on costumes were quite inaccurate. His renderings of tipis were all the same size and his renderings of earth lodges are portrayed as domes without the covered entryway and again depicted as all the same size. However, his ethnographic descriptions of Native American Indian life are significant (Hassrick 1977). The ethnographer Edward S. Curtis (1899-1929) photographed Native American Indians and their associated artifacts in their natural settings. Although his photographs are helpful to archaeologists and anthropologists, by today's archaeological standards they are flawed. His photographs were often contrived for aesthetic purposes. His images were more romantic and artistic than documentary and realistic. However, his photographic renderings and field notes are rare documentation from a time when most white Americans saw nothing to record or save of the indigenous Native American Indians (Lowry 1994).

Photographic renderings have played an important role in archaeological research. An essential use of photography in archaeology is to record valuable information about provenience. Take for example the photographs Hiram Bingham took in 1911 when he discovered Machu Picchu. His photographs and drawings of the architecture of Machu Picchu were studied by archaeologists and added to the accumulation of scientific knowledge concerning the Incas. Bingham's camera equipment was heavy, bulky and tedious to use as well as capable to producing only black and white prints. These factors limited what he could capture in a photograph although he was prolific; he took 2500 photographs in hot and humid weather, as well as in many instances with poor lighting available (Bingham 1913). The introduction of smaller, less cumbersome models as well as

color film, followed by polaroids, underwater cameras and now digital cameras has made it possible to use cameras in new ways at archaeological sites. For example, before the invention of the camera only drawings of archaeological sites captured the in situ data on placement of artifacts and provenience along with the nuances of artifacts, skeletal remains and even the textures and stratification of soil. But improvisation and the use of any type of rendering technique in the field are still necessary in remote areas.

One problem with studying renderings is that the renderings produced by individuals can be influenced by the renderer's own perspective, interpretation and their own reasons for producing the renderings in the first place. These aspects may skew the data for others who use the information for their own alternative purposes and theories. At any point in time, as much data as is felt relevant will be gathered from an original artifact to study. When the original artifact is no longer available to study potential data may be lost because the rendering was made for a certain set of specific purposes which may not have considered aspects of the artifact that the new research project wants to study. If the person doing the drawings is not proficient at drawing, a skew in data through the perspective and inability to achieve accuracy of the drawer of the artifacts can occur. Capturing the accuracy of provenience can also be at risk for these same reasons. Cameras have the same problems in almost all the same ways as drawings including the fact that only a two-dimensional look at an artifact is possible with them (Fig. 1). Take for example figures 1a and 1b; Figure 1a is a drawing of a Clovis point. The process of reproducing drawings (in books or on the internet) can distort details of the artifact such as wear patterns on the point as well as distort the size of the artifact. Even photographs, such as the picture of a drill in figure 1b, can be distorted. The text accompanying the

photo of the drill states that it is three inches in length and one and one-quarter inches wide at notch protrusions. However, if you measure these two points on the photograph the drill would appear to be four and three-eighths inches in length and one and nine-sixteenths inches at the notch protrusions. Due to these types of factors, the study of renderings can have a controlling effect on the nature and production of scientific knowledge. One has to be careful when building on the assumptions of what others have done before them even when using renderings.



(Fig. 1. 1a.) drawing of Clovis point base found at Ray Long site (www.augie.edu/), 1b.) photo of stone drill (Hothem 1984)

New Rendering Technologies

In the past few decades, a number of new techniques and technologies have been introduced to aid archaeologists in rendering artifacts and skeletal remains for analysis,

most of which revolve around the use of computers. There are a number of alternative computer-rendering methods for gathering, preserving and redistributing data about artifacts. With the computer capabilities of today, image formatting and mass media preservation offers fast and easy access to research materials. Now with the use of computers and lasers there are a wider range of different technologies to capture and disseminate data such as laser digitization/computer 3-D simulations or photogrammetrices.

Images of three-dimensional artifacts have been successfully made with the laser digitization technique. The image or model of the artifact can be replicated through the use of computer aided design (CAD) applications. The artifact to be scanned by the laser is usually mounted on a rotation device. The artifact's complete physical configurations can be mapped using a reflected laser beam that can be analyzed and recorded by a computer. The computer maps the physical configurations turning them into a mesh of connected dots. By using CAD files, large databases of artifact information and artifact images can be compared and catalogued for research and study. The points representing the artifact known as the point file are about 2MB for a medium sized artifact such as a piece of pottery. These points are converted into a mesh pattern in the computer which is a file that is compatible with a CAD application. For example, a 2MB point file could end up as a 10MB .stl file. Archaeologists with access to laser digitization equipment could easily make a scan of an artifact and show it to colleagues and scholars through the CAD file by the use of computers and e-mail (Kappleman 1997). New findings and data images can be disseminated immediately eliminating the lag time that usually takes place after discoveries are made.

Large digital data-bases in the form of CD ROM also provide a new application technology for archaeology. A three-dimensional animation can be produced on a computer by using CD ROM (fig. 2). To preserve three-dimensions, these files must be accessed on a computer that is capable of displaying them (i.e., has adequate RAM, hard drive, CD-drive, etc.). J. Kappleman, a professor in the anthropology department at the University of Texas, has successfully produced and used CD ROM to provide color high-resolution digital images of a human osteology guide that links and provides detailed elements of human bones to one another in a three-dimensional format (www.dla.utexas.edu). However, as seen in figure 2, when a print out is made of a three-dimensional image, only a two-dimensional single angle rendering is produced. Such images thus have many of the same disadvantages as drawings or photographs.

Fig. 2. CAD print out of ball joint (www.info@cyberware.com)

A major draw back of this system would be the absence of any type of tactile information and nuances an archaeologist could detect from the originals. For example, the fine detail of quill and beadwork on a pair of Crow ceremonial moccasins could not be

closely examined through a computer. Another disadvantage would be the length of time is takes for the laser to scan the objects thoroughly to be put into computer language. For example, it takes three hours of non-stop laser scanning to scan a human skull. A laser scanner, a rotating table, a computer and software to be able to read the laser scanner's data, and another computer-controlled laser are needed to take down the anatomical data and store or sculpt a rendering. Such equipment is expensive. To replicate a skull in polycarbonate material, for example, required a laser scanner that costs $100,000 along with the CT scanner and Sinterstation 2000 at a cost of $600,000 (Bower 1994). Even with these draw backs, it is faster than what has been the usual way to disseminate data.

The technique of photogrammetry is used to make measurements for maps from photographs that are usually taken from an aerial position, but this can also be applied to terrestrial or ground level close-range photographs of artifacts. It is necessary to take a pair of photographs for an accurate measurement because one photograph would distort the perspective. The overlap of the two photographs is seen in three-dimensions by the use of binocular eyepieces that simulate human vision including depth. The cameras are located and mounted in relationship to the artifact, either horizontal or vertical depending on the artifact or structure. Horizontal and vertical structures need to be set up for framing the photographs so the computer can calculate measurements. An adjustable platform is needed to mount the camera along with a frosted plate that the artifact rests on as well as a camera movement system. Three lights are used (fill light, back light and main light) to produce the quality photos needed for the measurement of the artifacts. The major advantages to using photogrammetry in archaeology is that it does not disturb or touch the artifacts in any way making it useful when artifacts are fragile. It is also

accurate and consistent on small to medium artifacts such as arrowheads. Copies of fragile artifacts can be facilitated with the use of this technology. A draw back, however, is larger objects like pottery would be subject to a depth measurement error problem but taking photos from several different angles can adjust for this problem although it becomes more time consuming. Another problem is that the metric cameras and photogrammetry plotting equipment needed in this type of rendering process can be expensive and rather technical to use as well as cumbersome to set up and carry to sites. However, the photographed image that is converted, in this case, by a computer in order to measure the artifact accurately can be useful for archival purposes (Fussell 1982).

Through the use of the new combined technology of photogrammetric and computer software systems a transferable rendering method for archiving and utilizing collections of historic and prehistoric artifacts for research has been produced. This was done by assembling metric data from stereo pairs of standard 35mm photographs taken of artifacts. This method can be used by archaeologists to archive high-resolution color images of artifacts and it will allow them to collect accurate three-dimensional metric data from the images. To produce measurements of pottery, for instance, where profile and rim thickness are valuable besides the usual measurements of width, length and depth, additional photogrammetic stereo pairs from different angles would be taken making it more time consuming and costly to generate renderings of artifacts (Gisiger 1996).

The major advantage of any type of renderings, of an artifact is that something is better than nothing. Any data gathered is useful but with new technological advancements more data could be gleaned from artifacts than have been in the past. However, even with the CAD process, when a printout from the computer is made, it is still only two-

dimensional.

Holography: A Viable Alternative

Given the limitations of these types of rendering techniques, I am proposing that a more complete rendering of artifacts could be accomplished through the use of holography. This non-invasive rendering technique can be used to record holograms of Native American Indian artifacts and skeletal remains. This non-invasive procedure would be an excellent way to add another dimension (three-dimensional) to, as well as to demonstrate in three-dimension examples of repatriated artifacts to scholars and students alike. It would also be an excellent way to inventory and catalogue Native American artifacts. While admittedly holography has some drawbacks, on the whole it does give a valuable three-dimensional property to artifacts and skeletal remains and adds another rendering technique to deal with the loss of artifacts to scientific study. The same issues surrounding NAGRPA would apply to the use of holograms for documentation, study and display as it would for photographs or any other form of renderings (i.e. religious and ethical issues).

The term holography comes from the Greek terms; holos meaning whole and graph meaning message. Holography is the recording (construction) of wavefront interference patterns created by coherent (laser) light sources and the replay (reconstruction) of these patterns as visual images or other forms of wave media. Holography is a way of reproducing a complete illusion of the reality of an object (Tyler 1989). The most striking characteristic of a hologram is its three-dimensional properties. Additional information and realistic/rendered properties can be seen and obtained from a hologram that are impossible to obtain from a typical two-dimensional photograph or

drawing such as those commonly used in archaeology. A typical photograph or drawing collapses into one plane, that of the plane of print, all the depth and spatial properties of an object. With a hologram the viewer is able to move his head from side to side and up and down to be able to see the different aspects or dimensions of an object which makes it possible to interact with the hologram (Kock 1968: 75). It is possible to make a rendering of an artifact, through the use of a hologram, that can show all the sides, top and bottom on a single hologram. A hologram then is an illusional rendering of space, time and dimension.

How Holography Works

The process of drawing together the components to produce renderings of Native American artifacts in such a three-dimensional holographic manner could not be accomplished if it were not for the invention of the laser. The forerunner of the laser, the optical maser, was developed in 1951 by Dr. Charles Townes, a physicist in quantum electronics. In 1958, he and Dr. A. L. Schawlow published the first theoretical description of an argon laser. This led to the development of the man-made ruby laser in 1960 by Dr. Theodore Maimam. Out of the process used to create the energized pure coherent light beam the acronym Light Amplification by Stimulated Emission of Radiation was born.

In order to understand the laser, it is necessary to understand the properties of light and its spectrum. Everything we see as having color is composed of pigments that assimilate some of the colors present in light and reflect others back to our eyes. If there were no light there would be no color for it is necessary to have light to get a reflection. For example, we see something as red because all the other colors are absorbed except red and that is reflected back to our eyes. White light or the light we see is made up of colors

and for each color there is a separate wavelength. This form of light is called incoherent because these wavelengths are out of step or phase with each other and are mingled or jumbled together in a disarray of varying divergent directions (Fig. 3a). One has only to look at white light through a prism or soap bubble to see the various colors in the spectrum that make up white light.

Laser light, however, is made up of only one color (i.e. red) or wavelength. These (red) wavelengths stay in a compact form and are in constant step or phase with each other which is referred to as coherent light. These (red) wavelengths travel parallel to each other and move in one direction (Fig. 3b). The laser beam therefore stays in a straight, constant and narrow beam for long distances (Boraiko 1984).

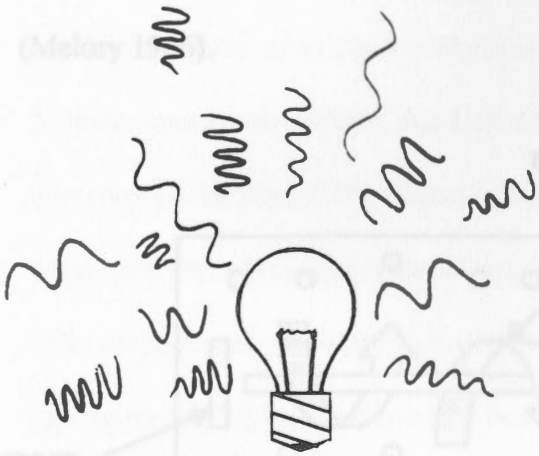


Fig. 3a White Light/Incoherent
adapted from Abramson 3

Fig. 3b Laser Light/Coherent
adapted from Abramson 3

A ruby laser, in this case a helium neon laser, works by harnessing the energy of atoms.[2] The laser (Fig. 4) is made up of a synthetic ruby crystal in the form of a slender

[2] This is the type of laser used in the Art department at Saint Mary's College were I was given access to the holographic equipment and shot the various holograms used as

rod that is polished and silvered at both ends forming mirrors. One mirror is totally reflective while the other is partially transparent. Also enclosed in the metal casing besides the ruby rod and the mirrors is a flash tube. When the flash tube is activated, it sets into motion or excites the photons contained in the chromium atoms of the ruby crystal. Electrons in the atoms jump to a temporary higher energy level and as the energized electron falls back to its original level a photon is given off. The photons given off are in the form of a small burst of light. Most of the photons given off bounce back and forth between the two end mirrors. As this happens they trigger or energize other electrons and their photons given off oscillate or line up in the same wavelength and travel in one direction. This all transpires in a thousandth of a second bringing forth a flow of photons that emerge through the partially reflecting mirror in a brilliant burst of coherent laser light (Melory 1966).

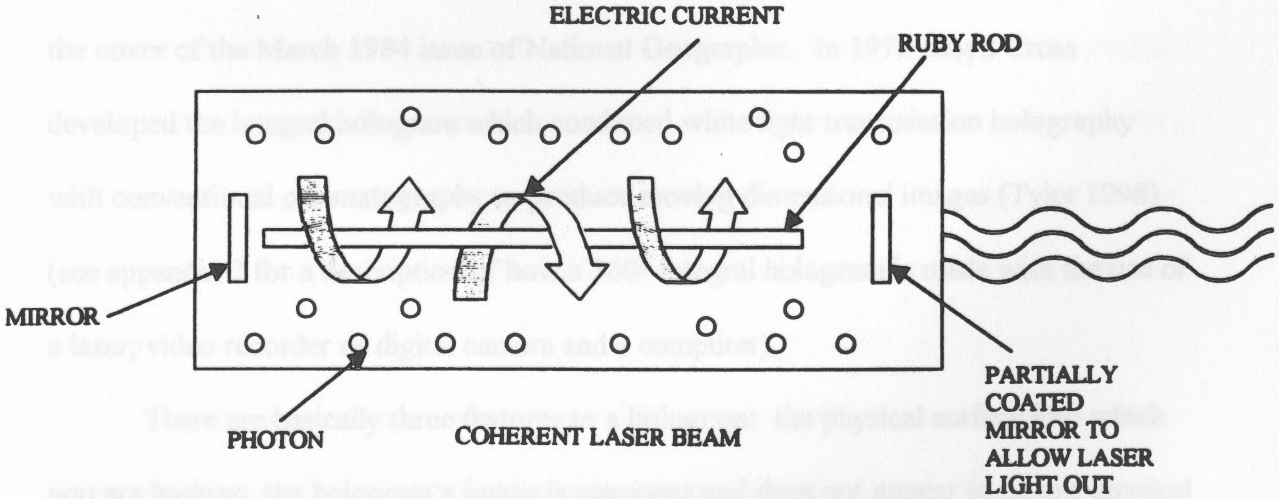


Fig. 4. Inner workings of a laser

There are a myriad of uses for the laser in fields such as medicine, science,

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examples for my thesis.

education and entertainment. Another use of lasers is in creating holograms through the process of holography. The hologram came into being quite by accident as Dr. Dennis Gabor in 1947 was searching for a method to improve the resolution of the electron microscope. He found by comparing the light shining through an object with a standard reference light he could record the brightness and the spatial relationship of one point of light to another, resulting in a phase comparison and this phase comparison is one reason that holography is unique. Gabor produced the first transmission hologram in 1948 without the use of a laser but when Maimam created the first laser the field of holography was born. Juris Upatmieks and Emmett Leith at the University of Michigan used a laser to make the first off-axis reference beam holograms. In 1965 the first single beam 360 degree transmission hologram was made, followed several years later by Steven Benton's production of the white light transmission or Rainbow hologram that created an image from the seven colors which make up white light. This type of hologram was featured on the cover of the March 1984 issue of National Geographic. In 1972 Lloyd Cross developed the integral hologram which combined white light transmission holography with conventional cinematography to produce moving dimensional images (Tyler 1998) (see appendix 2 for a description of how a 360° integral hologram is made with the use of a laser, video recorder or digital camera and a computer).

There are basically three features to a hologram: the physical surface into which you are looking, the hologram's image is vaporous and does not appear to have a physical presence (i.e. you may be able to touch the image itself, but you do not physically feel anything), and some form of special lighting is involved. Since a hologram's image is comprised of light, created by the ability to bend light in a highly sophisticated and

controlled manner, some form of light is needed to illuminate and replay or reconstruct the holographic image (Tyler 1997). There are two types of hologram images, the real and the virtual. A real image of an object appears in front of or is projected out from the holographic plate and appears to be floating in space while a virtual image of an object appears to be floating behind the holographic plate.

There are two main types of holograms, the type that must be replayed using laser light or partial coherence of light which is used mainly in scientific and technological applications because of the expense and technical set up for display and those that can be replayed using white light which is used mainly in display holography. This type is easier to set up and relatively inexpensive, which makes it ideal for use in museums, classrooms and for general research purposes. Of these two main types of holograms there are different categorizations and variations depicted by the techniques used to record them. While other variations do exist, the four basic types of holograms are the reflection, the transmission, the integral and the embossed. Deciding what type of hologram to produce depends on the purpose for which it will be used. For example, if the hologram is to be used in a textbook, the embossed type would be the proper choice. The space of an area where the hologram would be used (i.e. in a museum) would also determine the type of hologram.

One way to distinguish between the different types of holograms is how they are played back and viewed. The reflection hologram must be illuminated from the same side as that being viewed, usually from overhead. The light is partially reflected back at the viewer enabling the viewer to see the object's image. The transmission hologram is illuminated by passing light through it from the opposite side from which it is to be

viewed. The integral hologram combines movie imagery and holography. The subject is captured on movie film. After the film is developed, the individual frames are exposed holographically onto holographic plates. Each frame is exposed as a condensed vertical line. These multiple cinema frames are exposed sequentially side-by-side so that when viewing the image each of our eyes sees separates frames but fuses them stereoscopically. As a result of this fusion of frames the mind perceives space (Tyler 1997). This type of hologram is usually displayed in a cylindrical fashion that is usually illuminated from inside the display having a rainbow effect.

The embossed hologram can be created in large numbers once the metallic mold, that is covered with a fine layer of nickel, is made. The flexibility and versatility of this type of hologram permits it to be used in a variety of ways, from anti-fraud credit card devices to covers of National Geographic magazines (Memories in Light 1984), they can also be used in text books or as handouts in the classroom. The viewing of the embossed hologram, which has a shiny metallic backing, is similar to the reflection hologram. The reconstructing light source comes to the hologram from the same side as the viewer. The light can be from any white light including the sun.

The way in which holography works relies upon the creation and recording of the interference and the fringe associations (Fig. 5) of a coherent light source from a laser. This light source furnishes a more orderly pattern of wavelengths and thus a more highly resolved image. Captured on a light sensitive medium, such as film or glass that has been coated with a chemical emulsion, a hologram recording is that of the light waves that are reflected from an object that have been illuminated by laser light which, in turn, form a complete and full dimensional image of the original object. The hologram contains the

recording of the light field given off by the object that is the same field that the human eye normally perceives.

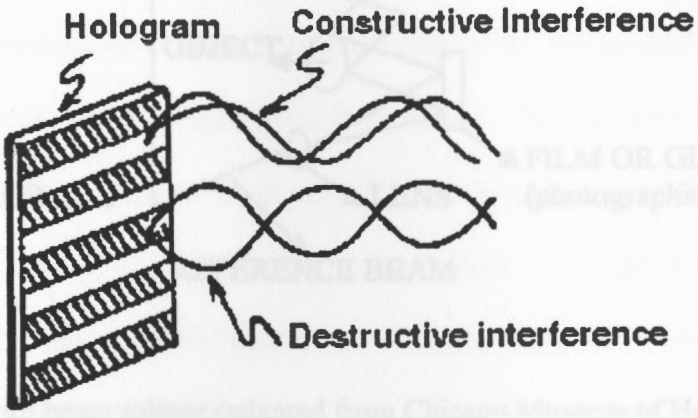


Fig. 5. Constructive and Destructive Interference Patterns (Outwater 1975: 18)

A Holographic Process

A simplified version of a two step holographic process that is shown in Figure six is as follows for the recording and reconstruction of an off axis transmission hologram. Although I could have used a more simplified or a more complex technique to explain the processes used to produce holograms, this one, a middle of the road technique, gives a good overview of the processes. The first step is light from a laser is passed through a beam splitter to create a reference beam and an object beam (Fig. 6). These two beams are then sent on different paths via the use of a beam spreader and mirrors. By using one laser to produce both the reference and object beams it ensures that a necessary coherence between them will take place. The film or glass plate which is covered on one side by an chemical emulsion sensitive to light is set into place where the two beams interfere. The object is placed in relationship to the emulsion side of the glass plate or film.

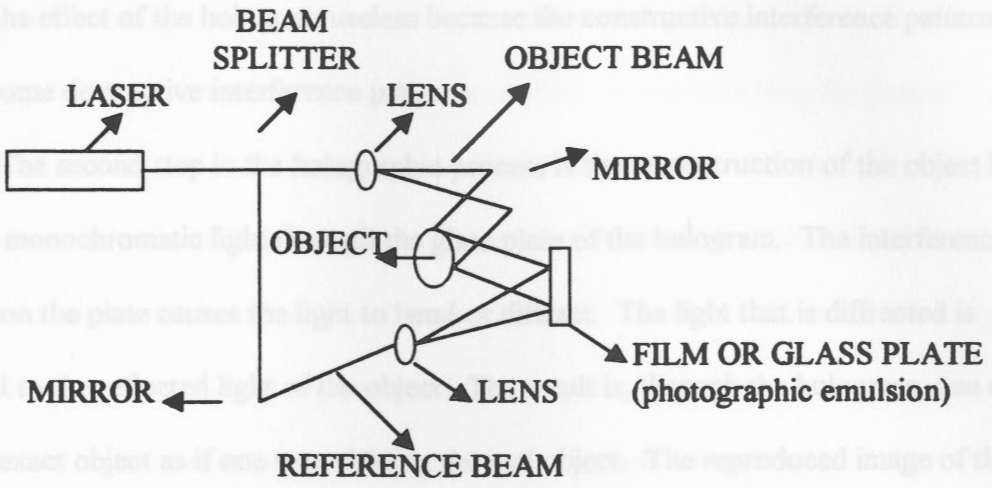


Fig. 6. Laser with beam splitter (adapted from Chicago Museum of Holography)

The object beam illuminates the object while the reference beam travels on a path to the emulsified plate to interfere with the light reflected from the object. The plate is exposed to the beams from the laser for only a few seconds which is time enough to capture the interference pattern. (Light waves that have their crest together or are in phase with each other produce a more intense wave while waves whose crests are opposite or in antiphase with each other cancel each other out and darkness is the result. However, when two waves combine to produce another wave it is called interference.) This time frame is dependent on the brightness of the laser and object. The hologram is formed where the light wave interference pattern is recorded on the emulsion side of the plate. The plate is then developed in the same manner as a photograph with developer, bleach and stop bath but the process is done with chemicals that are different from photographic development chemicals. The process is carried out under a green safe-light instead of the red safe-light used in photography (Wenyon 1978). The key to recording a well-defined and clear hologram is to have no vibration because the least vibration will

render the effect of the hologram useless because the constructive interference patterns will become destructive interference patterns.

The second step in the holographic process is the reconstruction of the object by passing monochromatic light through the glass plate of the hologram. The interference pattern on the plate causes the light to bend or diffract. The light that is diffracted is identical to the reflected light of the object. The result is, through the hologram, one can see the exact object as if one was viewing the real object. The reproduced image of the object, through the use of the hologram, is seen from the angle of the reflected light, with all its depth and parallax (Wenyon 1978).

Limitations of Holography and Their Solutions

While holography effectively deals with the issue of dimensionality, there are still limitations to the process. In some cases the size of the glass recording plate limits what artifacts can be recorded. For example, if you only have a 4x6 inch glass plate to work with it would be impossible to capture the full size headdress of a Lakota War Chief. The size of the artifact and the size of the plate have to correspond to each other. Another component that contributes to what can be recorded as a hologram is dependent on the size and type of laser along with the other equipment used to record a hologram. Something as small as a single bead can be recorded and they can be as large as the University of Nebraska's hologram that is two floors tall. There can also be a loss of actual artifact coloration because of the way a laser produces the artifact's image and the type of chemicals used to develop the hologram. True color holograms are expensive and difficult to achieve because of the type of laser and film needed to achieve them.

The chemical mixtures used in developing the holograms also play a factor in the

outcome of the hologram. Fresh chemicals, careful measuring of the chemicals and sometimes different mixtures of chemicals are needed. Along with this, the type of chemicals mixed together can change the color of the holograms. For example, if in the developer the mixture of chemicals has a preservative added such as phenidone, the result is a greenish tint to the hologram; on the other hand, if it is left out the result is a hologram with a reddish orange tint. In large scientific laboratories where the most sophisticated equipment is used, however, true color can and is achieved. (Munday 436-443).

Coating of several types (usually a powder) can be used in some cases to help produce a hologram that is brighter when viewed. This can be a problem however, when no coating should be applied to the original artifacts in order to preserve their integrity or where damage to the artifact would occur. However, in a case where it is a lithic artifact the powder substance can be removed fairly easily with no harm to the artifact.

Another solution to counter some of these problems would be to increase the laser power and the time needed to record the interference patterns of an artifact to produce a hologram. A problem can arise if the artifact to be recorded is not very bright itself (i.e. a black ax head or black piece of pottery) and or the artifact has a deep dimension to it (something like a headdress of a Plains Indian Chief). The closer the glass plate is located to the object to be recorded the better the quality of the hologram (in other words the coherency is better).

However, a higher beam intensity can be achieved by using a beam splitter in the set up for recording a hologram which can take care of some of these problems. A beam splitter divides the laser beam in two, an object beam and a reference beam that will both illuminate the artifact independently (Saxby 1994). In this way the object beam intensity is

increased in relationship to the reference beam resulting in a crisp hologram of the artifact being recorded. Some of the other limitations have been dealt with by integrating holographic stereogram technology and computer imaging technology (Munday 1995).

Because of the lack of mobility of the many pieces of equipment that are needed to record holograms, the artifacts would have to be transported to the equipment. Either that or all the holographic equipment would need to be moved to and set up where the artifacts are located which causes a problem because provenience cannot be recorded with the use of holography at least with the present technology. A room that is light proof, has electrical outlets and is large enough to accommodate the equipment is needed to insure that a successful hologram is achieved. To mount, stabilize, configure and set up the laser and the associated equipment to record the hologram and develop it is time consuming; however, once set up for recording an artifact the rest of the artifacts can be done in a timely manner.

Vibration, movement and stability of the object are probably the greatest problems as well as being frustrating to the holographer. Using a ruby pulse laser to record a hologram can help in this area. In holography the length of time needed to record the interference patterns of the object's image from the object and reference beams can be disrupted easily. Factors involved are the laser's power, the emulsion on the glass plate or film, and among others the reflective properties of the object you are dealing with. Movement can come from a myriad of sources; movement of any sort of the object, film/glass plate, and any acoustic vibration, such as close proximity to large elevators or large blowers in a heating or air conditioning system can ruin the hologram. To overcome this problem it is essential to isolate all components from any and all sources of movement

(Outwater 1975). One solution or option to resolve the problem of vibration or movement would be to use a pulse laser to record the holograms. This type of laser does not have a steady beam of laser light. Its energy is released in a split second burst of laser light. This allows less time for vibration or movement to occur.

Given these types of limitations with holography, it is clear that some specific guide lines for the type of Native American Indian artifacts and skeletal remains that would lend themselves to the holographic process are in order. This list is by no means an inclusive or exclusive list but in a general sense typical of what artifacts can be cost-effective to render through the technique of holography. Lithic artifacts of all sorts (i.e. arrow points, scrapers, drills, spear points, etc.) with color variation and size would work (see appendix 3). Even darker lithic artifacts will work if a holographic powder is applied to them. However, when looking at or studying those particular lithic renderings one has to take that into account. Smaller pieces of pottery as opposed to large ollas and pottery shards can be cost-effectively reproduced along with baskets and as well as pipe bowls, medicine bags, quill and bead work on various pieces of clothing. Other specific criteria used in deciding which artifacts should have holograms made of them would be the uniqueness of them along with the accessibility to scholars. If only one or a handful of a specific type of artifact exits it becomes extremely difficult to study it/them because of the likelihood that who ever owns them would not let them out of their control. Another type of criteria would be if there is a conflict over the interpretations of specific artifacts. The repatriation of artifacts is a key factor in the decision making process of which artifacts should be considered for the rendering technique of holography for when artifacts or skeletal remains are given back and/or reburied all new information that could be gleaned

from them is lost.

A way to make it possible to compare two or more artifacts is through the technique of holographic interferometry, an application by which a single hologram can record more than one or several successive images (Yavtushenko 1981). This can enable archaeologists to determine or demonstrate the slight variants and or similarities in artifacts such as defect localization as well as other characterizations of the artifacts.

The cost to set up a holography lab can be relatively inexpensive for a small lab or relatively expensive for a well-equipped and more versatile one (see appendix 2). However, any institution of higher education can overlap the use of a laser and its cost through interdepartmental use. The physics department could use the laser for experiments, the art department for use as a multi-media art form, and the anthropology/archaeology department could use it in recording holograms of artifacts and skeletal remains. It could also be used in interferometry to study microwear on such things as points, scrapers, other tools and bones.

The Benefits of Holography for Archaeology

Through the use of holography the many skeletal remains and artifacts that have been scheduled for repatriation can be replicated, inventoried and catalogued for future research and display. The moral and ethical issues as presented by some Native American Indian tribes over using ancestral remains and ceremonial artifacts could be negotiated in a different way. These items can be studied and viewed through the use of holograms. Again, here Ted Frisbie emphatically states that "it is absolutely essential to use any kind of tool (including holograms) to document and store as much data as possible about Native American artifacts and remains" (Frisbie, 1998).

In the case where multiple sides or the whole artifact are essential, when every detail of, say a fragile Mimbre bowl is needed, it could be replicated by the use of photographs. But photographs alone can not do justice to the visual image of the full dimensions of a pottery piece as holograms can. The piece can be replicated and furnished through the use of a circular reflective hologram even though it would be very intensive to do. However, it may be well worth the cost and effort to make the hologram. An alternative holographic rendering method, which is easier and less time consuming, would be a two-sided reflective hologram. The use of a single glass plate to record separate holograms of the obverse and reverse of an artifact can be done in such a way that when reconstructed both images exactly coincide. "The more data gathered the better, specially if the color of the hologram is accurate to the artifact" (Schurr 1998).

With the breakthrough of a new film and processing technique, full color holograms are now possible. True color holograms have 10,000 lines per millimeter of resolution compared to only 3,000 lines per millimeter for monochrome holograms and only several hundred lines for photographs (Fischbach 1995). This breakthrough can lend credence to the use of holograms over photographs as a rendering technique for some Native American Indian artifacts.

Holography can also be a valuable tool to bring together similar artifacts that have been scattered all across the country and the world. It would enable researchers to share research materials and information without having to physically transport the original artifacts or to go themselves to the artifacts to study them. Through the use of holography then, the compiling and anthologizing of scattered artifacts along with the replacement and acquisition of simulated artifacts is possible. As Mark Schurr stated, in

the accumulation of knowledge today it is essential to study the renderings of artifacts that are disseminated because it is not possible to travel to places where the artifacts are located (Schurr 1998). It becomes crucial that the renderings of artifacts and skeletal remains be accurate for otherwise what research and knowledge is produced with inaccurate renderings can have a negative or skewing effect on scientific knowledge.

Already holograms have been successfully used by museums to reproduce images of rare and fragile artifacts. Yuri Denisyuk, in the former Soviet Union, in 1962, was the first to use holography in this manner (Saxby 1988). By producing holographic replications of rare and fragile artifacts from Russian museums, the reconstructed real/pseudoscopic images (images that exist in the viewers' real space) of these objects could travel to other museums. This allowed renderings of artifacts to be put on display elsewhere without having the original artifacts leave their home museum. In 1989 the head of the Applied Holography Laboratory of the Ukrainian Academy of Sciences, Vladimir Makov, oversaw the making of holograms of rare artifacts from fourth-century Greece. Because of Mokov's efforts a hologram of a gortus, a Greek bow and arrow case, not found in other places in Europe, can now be seen in the West for the first time. These types of archaeological artifact holograms can provide an opportunity to study rare and fragile artifacts from relatively unknown parts of the world (Morgan 1989).

Holograms could also be advantageously used to replace laborious castings of artifacts allowing optical replicas to be used in research, rather than the perishable, valuable and rare original artifacts. Another advantage of using holograms in museology and archaeology is when taking a mold of an artifact would end up damaging or destroying the artifact. In this instance an exposed and processed plate can be rotated

through 180 degrees in relation to the source of light in which a beam is directed onto it. The resulting hologram is a real/pseudoscopic rendering of the artifact (Yavtushenko 1981).

Given the diversity of the use of a laser and its non-invasive properties, it can prove beneficial to archaeology by recording, through holography and the hologram, renderings of artifacts and other materials that come under the repatriation laws of NAGPRA. Like a hologram, archaeology also deals with space and time to try to discern the whole of the past from what artifacts are left behind. Institutions of higher education and museums have long been storing and collecting historic and prehistoric materials such as bones and artifacts that were procured from archaeological digs, donations, purchases and other means.

Museum/Pedagogical Advantages of Holography

While they may not function under the same guide lines, museums and institutions of higher education do not only display artifacts but also function as repositories for data banks on artifacts used by the scholarly community as well as the keepers of earth's history and human history. There is a need for information retrieval, integration and intercompatibility of data analysis. Both of these institutions have been wrestling with the dilemma to find and implement a good, reliable, transferable and systematic method for utilizing and archiving their collections for research as well as utilizing them for training for students.

Crystal Welsh, who was the curator of the Woodlawn Nature Center in Elkhart, Indiana, has lent 35 artifact pieces that were part of a donated collection to the Nature Center on a permanent basis to the Pokagan band. John Warren, the cultural coordinator

for the Pokagan band, asked that the remaining artifacts that have ceremonial affiliation be removed from the displays; however, the Center could photograph and keep the artifacts but not display the photos or artifacts. Crystal Welsh believes a hologram of an artifact would be an added attraction to the Pokagan artifact collection and they would have representational use in displays to give the viewer of the displays a three-dimensional idea of what the artifact actually looked like (Personal interview, 14 July 1998). However, John Warren who follows the traditional Native American ways, did state that "renderings of any sort should not be allowed for ceremonial objects and human remains" for the spiritual images of these things should be pictured and held in the heart and mind (Personal interview, 29 Nov 1998).

Holography has already been used as a means of cataloging and display by the Smithsonian Institute. One such example from the Smithsonian is a white light transmission hologram of a mummy's skull, that was done for the purpose of providing a three-dimensional copy of a valuable artifact that was in danger of decay. Another example in which holography has proved ideal for archival recording of valuable and fragile museum artifacts was done by the British Museum as a means to preserve the remains of the Lindow Man. This preserved human body of a 2300 year old Iron Age man was unearthed from a peat bog in England. In this instance a pulse hologram was recorded so the reproduced psuedoscopic image of it could be publicly exhibited (Saxby 1994).

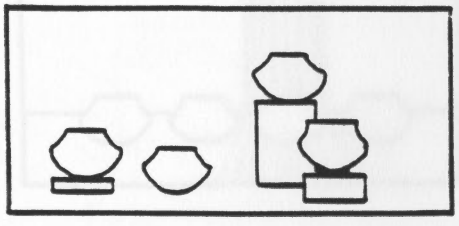
Museums can also use holograms to exhibit artifacts which must be viewed from more than one angle or side or from two sides at once to be able to view and appreciate the full esthetics and nuances of it (Yavtushenko 1981). For example, one can show both

sides of an artifact from the same side of an exhibit. Such an example would be the front and back of a ghost dance shirt like the one worn at the Wounded Knee massacre which the National Museum of Natural History repatriated to the Oglala Lakota Sioux (Chicago Tribune 1997). Another case in point of this type of hologram showing remarkable detail and quality is Mark Diamond's successful recording of many portrait holographic images of Native American Indians wearing their traditional dress and holding artifacts used in dance and religious ceremonies (Jeong 1995: 310).

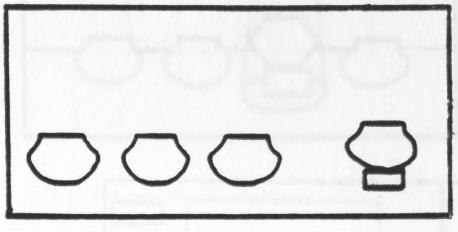
The holograms recorded from artifacts that are to be repatriated from museums could still be viewed in the same context of display as the original artifacts. Take for instance the diverse pottery of the Southwestern United States. The display could still be set up according to the pottery's design factors. For example, in figure 7a the emphasis could be through size, isolation, color, size and line placement, shape, texture, size and light or through a combination of any of these types as seen in figure 7b. In placement by size and at different levels in a display each pot is seen as distinctly different. By setting a pottery piece apart in isolation, attention is drawn to that particular piece. When using color as a focal point such as a polychrome piece of pottery as opposed to Mimbre black on white pottery attention is again drawn to the polychrome piece. When the pottery is all polychrome or Mimbre black on white a device such as lines being drawn to each pottery piece with text information and the use of size can also establish individuality of the pottery as well as direct the movement of the eyes. In using a flowing affect of materials in a display it can show chronology or transitional phases of the pieces of pottery. With the backdrop of a different texture being used the eye is immediately drawn to the piece that it highlighted by it. When using size and light dramatization of a particular piece of

pottery can be achieved. In figure 7b a display case with a combination of holograms, size, shape and isolation have been used. White light illumination for playback of transmission or reflection holograms would be best suited for museum display. In figures 7c through 7e varying set ups for viewing transmission and reflection holograms have been illustrated. Depending on the space that can be utilized for any given display will dictate the type of set up needed for viewing holograms.

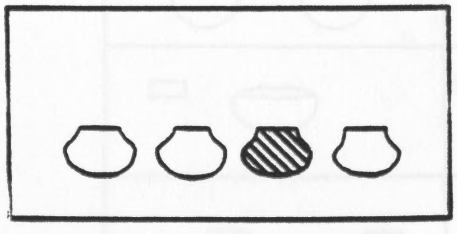
Figs. 7a (Neal 73)



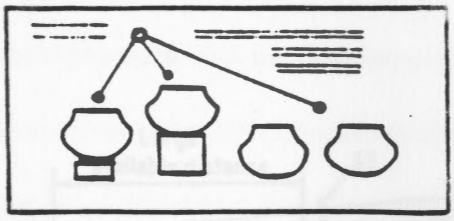
Placement and size



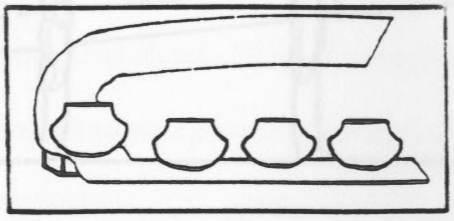
By isolation



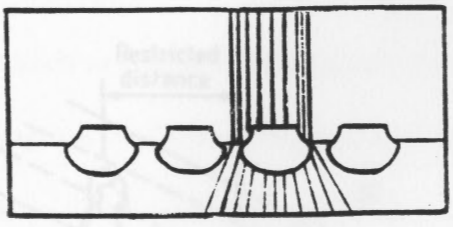
By color if possible



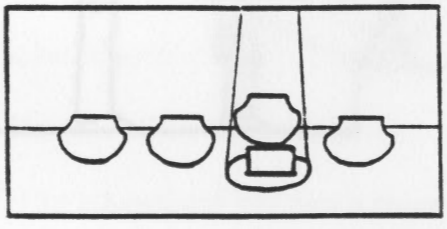
By placement, size and line



By shape using different materials



By texture



By placement, size and light

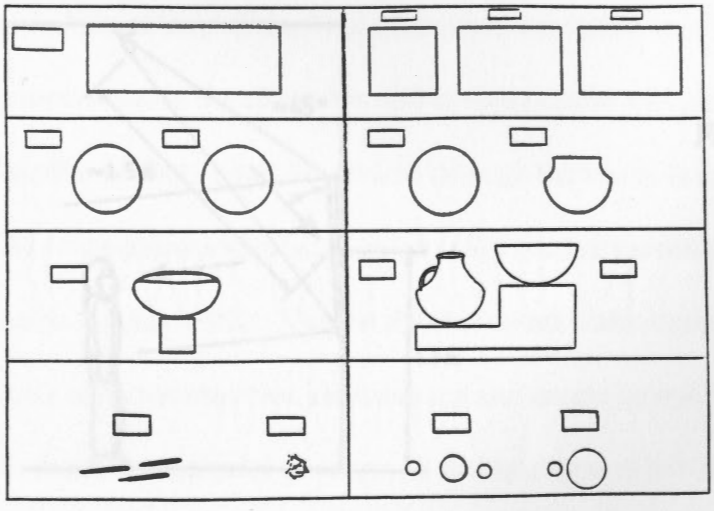


Fig. 7b Example of museum display utilizing both artifacts and holograms

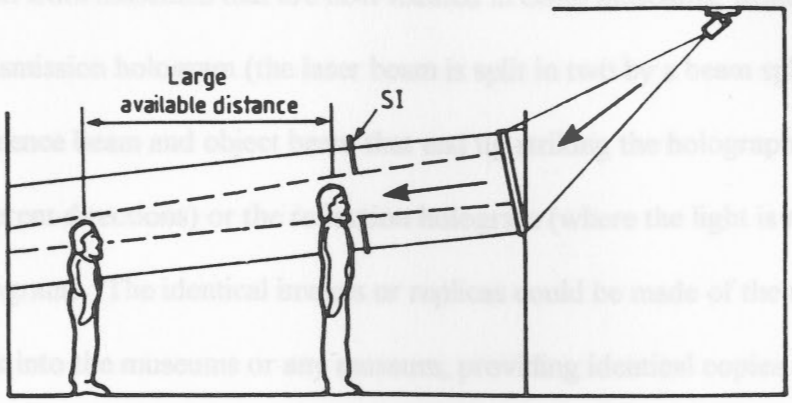


Fig. 7c Transmission
(Saxby 367)

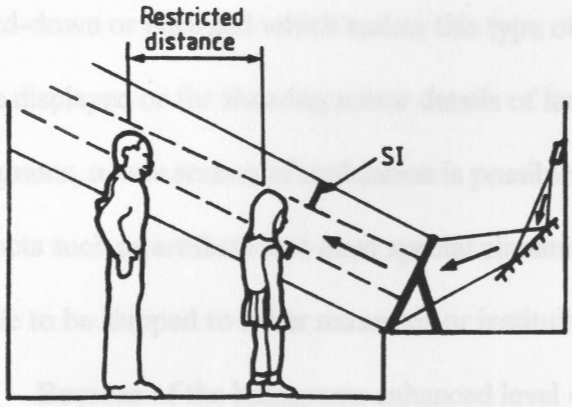


Fig. 7d Transmission
(Saxby 367)

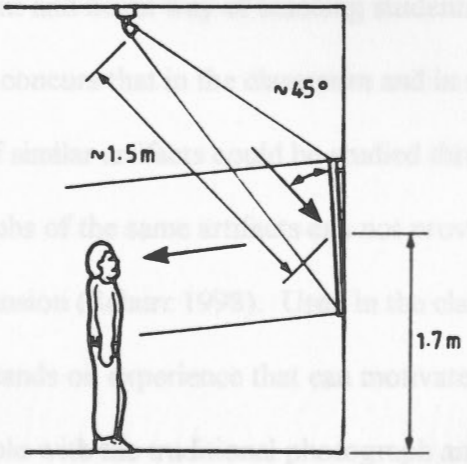


Fig. 7e Reflection
(Saxby 366)

The type of holograms best suited for the replication of the many ancient artifacts,

taken from museums that are now located in other museums, would be the off axis transmission hologram (the laser beam is split in two by a beam splitter thus forming a reference beam and object beam that end up striking the holographic glass plate from different directions) or the reflection hologram (where the light is reflected off the hologram). The identical images or replicas could be made of the artifacts and placed back into the museums or any museum, providing identical copies of the original artifacts allowing more people a greater opportunity to view them.

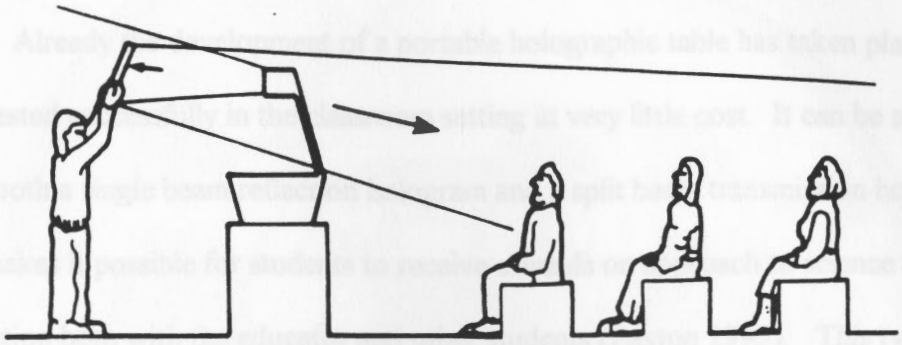
Through the use of holography, three-dimensional renderings of artifacts can be scaled-down or enlarged which makes this type of use beneficial when small artifacts are to be displayed or for showing minor details of large artifacts. With the application of holograms, a new source of replication is possible for many ancient, rare or perishable artifacts such as artifacts that need special climate control, special storage, are too rare or fragile to be shipped to other museums or institutions for research or teaching purposes.

Because of the holograms enhanced level of information storage it can potentially be useful for educational and data storage purposes. Holograms can provide instructors with a different and novel way of teaching students to recognize and identify artifacts. Mark Schurr concurs that in the classroom and in research the variant angles and slight differences of similar artifacts could be studied through the use of holograms where as the photographs of the same artifacts can not provide this information due to its limited plane of dimension (Schurr 1998). Used in the classroom, these three-dimensional images can provide hands on experience that can motivate and create interest in learning, which are not possible with the traditional photograph and text type of published books. As Melanie Wiber states in Erect Men Undulating Women, " . . . the imagery often sticks with

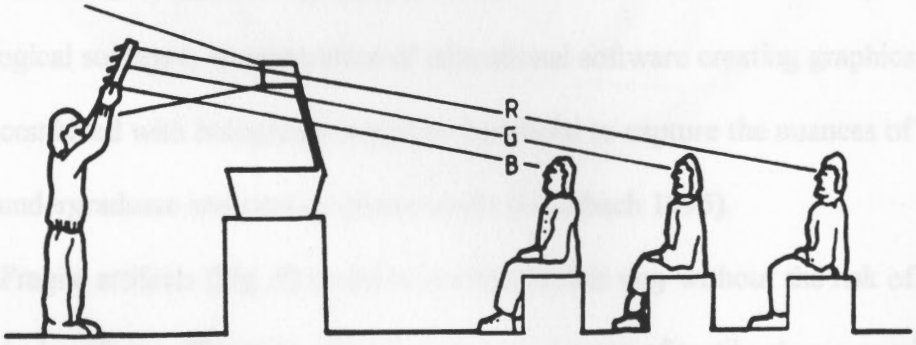
the reader longer than the text" (Wiber 2). The typical illustrations in textbooks are subject to the artists' varying interpretations and differing conceptions of the subject matter. Holograms are in addition a way to provide inexpensive models when expensive ones cannot be afforded. Holograms can be used to create a visual impact, there by, impregnating the minds of students with information they will remember. Reflection holograms have already been used by the 'World Book Encyclopedia' as illustrations (Wenyon 1978).

By using Stephen Benton's technique of white light transmission holography and employing the embossing technique of stamping the interference pattern onto plastic, it is possible to mass produce the same hologram millions of times at only a few cents each. This type of white light transmission embossed hologram made it possible for National Geographic, in November of 1985, to feature on its cover the one to two million year old, actual size, fossil skull of the South African Taung child (National Geographic 1985).

In the classroom overhead projectors can be used to display reflection holograms by holding the hologram in the correct angle to the projector's light source. It is necessary to align the hologram so the projected holographic image falls across the eye area of all the people in the classroom. In figure 8b a rainbow hologram is being viewed. The R is the red wavelength, the G is the green wavelength and the B is the blue wavelength that is seen. Each row, because of the unique properties of the rainbow hologram, can only see the particular color that is projected out from the hologram to the position they are seated in.



(a)



(b)

Fig 8. Overhead Projector Diagram (Saxby 364) (a) simple reflection. (b) rainbow

Holography is one form of a multimedia visual communication. The visual replica of an artifact that a hologram furnishes gives an exacting image for the purpose of demonstration in teaching, research, display and cataloguing. Both Dale Quattrin, the resident archaeologist at Indiana University South Bend, and Philip Drey, an archaeology instructor at Andrews University, agree that as a teaching tool holograms would be an excellent source to draw from in the classroom as representational substitutes and for

esthetic purposes (Personal interviews, 12 May 1998 and 20 April 1998).

Already the development of a portable holographic table has taken place and has been tested successfully in the classroom setting at very little cost. It can be set up to make both a single beam reflection hologram and a split beam transmission hologram. This makes it possible for students to receive a-hands on approach to science with interaction both with the educator and other students (Paxton 1995). This type of education can benefit both younger and older students, however, college level students' work could be more intense using holography and the computer to generate three-dimensional images. By utilizing computers and the new and ever advancing technological software, an integration of educational software creating graphics and images combined with holograms would be beneficial to capture the nuances of artifacts for the undergraduate and post-graduate levels (Fischbach 1995).

Fragile artifacts (Fig. 9) could be handled in this way without the risk of damaging the original artifacts. This type of arrangement of the use of tactile gloves or a joy stick could be used in museums or even libraries where volumes of inexperienced users would be involved (Jones 1995). When wearing the computer controlled tactile gloves a sensation of touching the artifact happens when the system detects the glove touching the plotted positions of the holographic image. To produce the haptic hologram a standard transfer master hologram of an artifact needs to be made. The master hologram is used to record a reflective transfer hologram with all the characteristics of the real image (it will appear to be floating in front of the holographic plate). This new possibility can be used as an educational teaching aid as well as being used as a hands-on display in museums.

Fig. 9. Mimbre Bowl (Carr 1979 plate 28)

By also using holography a more complete reference library would be available for future research on Native American Indian cultures. Storage considerations for the readily accessible holograms and data would need to be addressed by libraries. These reference holograms would make copies easily accessible for archaeologists and others to share research materials. Holography coupled with three-dimensional measurements from photogrammetry, computer digitizing and advanced software can prove to be excellent archival mediums for artifacts that will be repatriated to the various Native American Indian tribes.

Julie Long a research librarian at Saint Mary's College believes it would be fairly easy to store and lend out holograms of repatriated Native American Indian artifacts.

They would be bar coded and given an OCLC (original cataloging) number as books are and they could be referenced or stored in the archives which is more closely controlled, in the media center as are video tapes and recordings are kept and loaned out or on the reserve shelves where professors have required course materials for their classes stored for their students use (Personal interview, 16 July 1998). Given that holograms could be handled in the same manner as books, faculty and students would be able to access three-dimensional holograms to use in classrooms and for research and study aids. These holograms like books could also be made available for inter-library loan purposes.

Implications of Holography for Scientific Research

Inter-library loans of holograms, mass copying of photographs, drawings and almost immediate information retrieval from computer internet systems floods the world with reproductions or renderings. The high tech simulations of the world around us numb our senses and delude us into being comfortable with non-reality.

At the heart of today's postmodern world beats the rapidly developing technology of computers coupled with the dissemination of knowledge. This technology is causing archaeologists to adjust the way they go about their search for information about the past. Indeed a paradigm shift has taken place: the computer has become an invaluable tool to handle and manipulate massive quantities of archaeological data and to derive statistical information from artifacts. With the aid of computer programs, pieces of the puzzle can be combined to become simulated whole entire artifacts again, structures and pueblos can be re-created or rendered as close as can be possible to what they once were.

By using the new techniques of computer digitization that have sprung forth in this postmodern age, a paradigm shift in holographic technology has taken place over the past

decade. Now holographic images can be produced that are more sophisticated than what has been recorded in the past. "The full integration of holographic stereogram technology and computer imaging technology offers immense advantages for the design and production of holograms" (Munday 1995: 438).

The ideal would be to use both holograms and the appropriate combination of computer digitization computer software, that would in affect enable anyone to see the whole artifact at once not in the usual segmented parts of photographs or drawings. Holography is capable of rendering the artifact in complete dimensional accuracy of size, shape, texture, color and relative space. If the data represented by holograms can be used in the future for metric measuring and specialized metric comparisons of rendered artifacts it would be useful to archaeological research. Along with this a computer digital format of a hologram would be a plus (Schurr 1998) to the accumulation and dissemination of knowledge.

Both Lyotard and Baudrillard see the postmodern as the age of computers and renderings. This postmodern age driven by computer necessity, according to Lyotard, is a transitional period of rapid change from the modern. It is the globalization of language, information, norms and values. Knowledge and information are becoming the number one marketable product and computers are the means used to get the information around the world (Lyotard 1979).

Not only have paradigm shifts occurred in archaeology and holography because of computer technology but also a general paradigm shift can be seen in the change of status of science and knowledge in our postmodern world culture. Scientific knowledge does not represent the totality of knowledge anymore. Society also plays a part in knowledge.

These technological transformations are having an impact on knowledge in research and in the transmission of acquired learning, but the information and technology can only be used by those who have access to computers and the necessary computer knowledge. Knowledge has become a form of an informational commodity that involves the competition for power. Now, knowledge is produced, sold and consumed in order to be valorized. The goal is exchange, and as this goal, knowledge ceases to be an end in itself. Knowledge becomes power and who ever has this informational knowledge has the power. Symbolic exchange is dominated by the circulation of signs that are related through the computer. Even in the field of archaeology we find that sacred things also fall under this symbolic exchange. But to lessen the impact of the control over the power of who receives knowledge, in this instance in archaeological research, holograms can be produced and widely circulated to whom ever wishes to use them either in museums or the classroom.

What has transpired is that scientific knowledge is pitted against ethical, moral, religious and cultural issues. Scientific knowledge can no longer be counted on as truth for we now realize that we ourselves are creating and recreating reality through language and that there have always been a multitude of different realities all along created in each community. Through the use of computers our own communities now can be seen as part of one world community. We are not only creating realities through language but we are also creating meanings of the words and symbols that make up language. Once created, we conveniently forget that we created the realities in the first place and this created concept of reality becomes what we see and believe as real. Scientific truth is ultimately only one of many social foundations created by humans (Lyotard 1993).

The postmodern, according to Baudrillard, is a superficial world of simulation that is lacking affect and emotion. It is a depthless world with a loss of a sense of one's place in history, with a lack in the sense of difference of the past, present and future. The postmodern society is implosive with a flattening affect through only reproductive technologies (i.e. computers) (Ritzer 1996).

Symbolic exchange, through such things as communications, computers, information processing, entertainment and knowledge industries, has taken over production as an economic commodity. While signs used to stand for something real, they now refer to themselves and other signs. These signs can be thought of as self-referential. According to Ritzer (1996) and Gane (1991) reality has imploded causing our communication systems to change from a complex syntactical language structure to one of a binary system. What was once thought of as "real" can no longer be processed mentally in that manner. What is thought of as "real" is only a representation or rendering, a reification, that is taken as the reference model for what is "reality". The model is confused with "reality" and the model becomes the reference that is "reality".

In the world of holograms as with all other renderings, the rendering or simulation of the real artifact becomes the real and there is no longer a "real" reality of an artifact only a hyperreal one. The real is lost but the simulation of it becomes substituted for the real. "It is no longer a question of imitation, nor duplication, nor even parody. It is a question of substituting the signs of the real for the real . . ." (Baudrillard 1994: 2). "Representation stems from the principle of the equivalence of the sign and of the real" (Baudrillard 1994: 6). The sign and object become fused as one. The epistemological implications of using any simulations (holograms) in research denotes that we cannot

know and we cannot build onto knowledge in what has been the norm because we can no longer know the real because it no longer exists. Simulation covers up or hides the absence of reality.

In the case of a laser, then, the laser and its light waves are a simulation of the Sun and its light waves. Laser light is a simulation of the refracted/reflected light of the original artifact. The interference patterns captured on the hologram become the real and the bending of light that we see and that our brains translate into images becomes our own individual realities. The images become our own truths of what is real. As Baudrillard states, it is the hyperreal. "It is the generation by models of a real without origin or reality . . . " (Baudrillard 1994: 1). "It is the representations of the real, the simulations, that come to be predominant" (Ritzer 1996: 482), it is the representations of the real that are hyperreality.

Even though holograms may come as close or closer to any other renderings of the original Native American Indian artifacts, such as drawings or photographs which are typically used by archaeologists, they are not the artifacts. The hologram is only a rendering or simulation of the reality of the artifact in its own right, for one type of rendering is no more similar to another than they are to the original artifact. A hologram as other renderings ". . . never have reproductive (truth) value, but always already simulation value" (truth) (Baudrillard 1994: 108). It makes the rendering or sign equal to that of the real. The past is reinvented to become the real, to become assimilated into the collective history and prehistory of, in this case, the United States.

Scientific knowledge gleaned from simulations can be suspect for error as simulations or renderings of artifacts are always skewed by the perspectives of the person

or persons doing the rendering. There is always involved "the fallibility of humans themselves in the drawings, sketches and photos they do" (Quattrin 1998). The problem is in what the person doing the renderings "thinks is important . . ., I am not confident of the specific attributes based on the photographs . . . for accuracy is lost" (Quattrin 1998). Just as a photograph collapses the original three-dimensional artifacts into a single plane of a rendered simulation, knowledge taken from photographs or any other type of rendering is only simulated knowledge.

As Wiber points out, there is a need to look at how renderings and illustrations are given scientific authority and the " . . . epistemological issues of knowledge generation, and the interaction between institutional power and knowledge dissemination" (Wilber 1997: 239). Science is not always value-free. "Truth" is the perspective of each individual or group of individuals through their culturization and these perspectives are the byproducts of social interchange (discourse). These "truths" about reality are made, constructed, deconstructed and reconstructed out of our own thoughts that are arbitrary and internal and veiled in the language and social constructs of our societies.

What is becoming clear is that the NAGPRA laws need to have a definite clarification to them before what is left for archaeologists to study is only hyperreal. What NAGPRA is ultimately doing is scattering artifacts back over the United States making it more difficult for archaeologists and anthropologists to study them collectively. NAGPRA is also removing the artifacts from our reality and from any future changing of that reality due to the use of new technologies that might lead to a different interpretation of an artifact or site (i.e. DNA testing).

Stemming from the postmodern era that we are now experiencing, reproductive

technologies have become more common place to transfer the 'real' artifacts used in archaeology to merely simulations of realities. The information or knowledge production through the use of the superhighways of computers have become the economic commodity of the day. There is no longer human contact but we are set adrift to surf the net. It has become an age of non-human computers talking to computers, sending information through space over these superhighways of telecommunication satellites. If one is able to afford the computer and link up to these waves of information, one then can participate in the information sharing; if not they are left adrift in the implosive void of a black hole. A void of this same type of nature is being felt in archaeology and in museums as artifacts and skeletal remains of the Native American Indian cultures are being repatriated through the auspices of NAGPRA.

Archaeological data is subject to many different kinds of tests and methods of interpretation and research ends up being harder to do from renderings. A case in point would be doing DNA testing of skeletal remains and any blood that could occur on lithics. There can be different emphasis on data over time making the data set taken before the artifact's repatriation not conducive to the new research and study (Quattrin 1998).

A power play then by some Native American Indians has occurred. By taking back their culturally affiliated artifacts and osteological remains of ancestors, they are removing the real from science and knowledge and forcing simulations to be used as if they were the real artifacts. An implosion of a societal culture takes over.

As the ever changing information technology is integrated into the process of research and scholarly communication, the capturing, archiving and preserving of deteriorating information at the highest resolution is an extremely necessary requirement

for dissemination and use by scholarly disciplines in the future. Here is where the use of lasers, holography and especially computers and a combination of these three technological rendering devices will be essential for scholarly disciplines as the accumulation and dispensing of knowledge will be handled differently.

Conclusion

While I sympathize with and have a great deal of empathy and respect for Native American Indians and their cultural heritage, I also understand the importance of scientific research and the epistemological value in the ongoing need to search for truth. While arguing both sides of the issues I have presented here, I find myself straddling the fence on many of them. There is a need to build a bridge between these issues so everyone can work within the guidelines and that they can feel they are all working for the same common goals. Another issue raised for me by this project is whether science is truly value free. How does one separate a lifetime of learning and acculturation from one's research? How does one see the world as a child full of wonder and delight at the first encounter of something new and different?

Ideally artifacts would be depicted in renderings that convey the whole message not as others see or depict them. This should be done because renderings " . . . represent science and the kinds of knowledge produced by scientists . . ." as well as giving " . . . scientific authority to the uninformed . . . " (Wiber 1997: 205). What one person sees as significant, another may not, therefore, leaving out an aspect of an artifact that could be very relative to the next scientific endeavor. If artifacts are no longer available to study one has to accept on blind faith the accumulated knowledge that has been done by others. It becomes impossible to go back to the original artifacts to challenge what has been done

in the past as well as look at the artifacts through the eyes of the new generations of archaeologists and anthropologists. Although computers and the internet are wonderful tools for diseminating knowledge, it is to easy to add to, erase or change information in cyber space which lends itself to the creating of reality or what is taken as reality. It is too easy to point and click to maneuver information.

Unfortunately as with any other rendering technique, holography has some draw backs when coupled with archaeology. The nature of the equipment would make it cumbersome to move around and at this point in time in its technological stage near to impossible to take into the field to record provenience. It is also expensive at this time to achieve true color of an artifact in a hologram; however, technological advancements will bring down the cost in both in the field research and in true color holograms. However, when one takes into consideration the fact that artifacts and skeletal remains that come under the NAGPRA laws are already housed mostly in museums and institutions of higher education then recording holograms of these materials for future use would not be that difficult to accomplish. Since NAGPRA allows the photographing, catalogue and documentation of any material that is to be repatriated, holograms could be an added three-dimensional feature to this collection of information. Whether Native American tribes affiliated with these materials would allow or disallow the holograms to be displayed on moral or ethical issues would have to be resolved by the parties involved with each artifact or skeletal remain.

Holograms can be creatively used as teaching aids in the classroom to communicate information and data to students or to the general public in museum settings. They can also be useful as the representational substitutes for Native American Indian

artifacts that are repatriated. Depending on the type of hologram recorded and played back, accurate measurements can be taken from holograms by archaeologists and anthropologists for gleaning information about artifacts or skeletal remains for research (Tyler 1998). This has been successfully done with the use of Denisyuk holograms that were made with a collimated beam. This type of hologram allows measurements to be taken in any direction with the use of calipers (Saxby 1994). Holograms can also be a tool used to compare artifacts and skeletal remains that are in different collections scattered across the United States if not the World.

In many instances some type of representation of an artifact or skeletal remain is better than nothing, this nothing does and can happen when repatriation and reburial takes place. Even though holograms, like any type of rendering of artifacts, can prove to be useful, nothing can take the place of the original artifacts especially in the wake of the accelerated speed in which new technology is being produced (i.e. DNA testing). Holograms are useful not for depicting artifacts in a contextual manner but for recording them in a more novel and complete fashion before these artifacts and skeletal remains are lost to the scientific and public communities. What the holograms I have recorded show or demonstrate is that there is another rendering technology that can be used to document, catalogue, store data, be used as teaching aids in the classroom and be displayed in museums as representation illustrations of the repatriated artifacts. An added advantage to the use of holograms is that a master hologram can be kept for future use to produce additional holograms of the same artifacts in a three-dimensional manner even after the original artifacts have been repatriated and become inaccessible to study. It is an option other than what has been typically used. Information transmission is the core to any

discipline. New theories can create and add to the accumulation of knowledge as well as prove or refute existing ones, but this can only happen if original and very accurate renderings of artifacts and skeletal remains are available for study. As it was in the 1800's, when the Native American Indian was thought to be on the brink of extinction and a loss of artifacts and a culture looked inevitable, archaeologists and curators are now faced with the loss of the artifacts and skeletal remains they helped to preserve. Through NAGPRA, archaeology is becoming a science of sensory deprivation. Archaeologists will not be able to heft an artifact for a feel of weight or touch it for its nuance of texture. Knowledge and truth as we now know it may become, like a hologram, an illusion in space and time.

Appendix 1

PUBLIC LAW 101-601--NOV. 16, 1990

NATIVE AMERICAN GRAVES PROTECTION AND REPATRIATION ACT

Public Law 101-601
101st Congress

An Act

Nov.16,1990 To provide for the protection of Native American graves,
---------- and for other purposes.
[H.R. 5237]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Native American Graves Protection and Repatriation Act.
Hawaiian Natives.
Historic preservation.
25 USC 3001 note.

SECTION 1. SHORT TITLE.

This Act may be cited as the "Native American Graves Protection and Repatriation Act".

SEC. 2. DEFINITIONS.

25 USC 3001.

For purposes of this Act, the term-

(1) "burial site" means any natural or prepared physical location, whether originally below, on, or above the surface of the earth, into which as a part of the death rite or ceremony of a culture, individual human remains are deposited.

(2) "cultural affiliation" means that there is a relationship of shared group identity which can be reasonably traced historically or prehistorically between a present day Indian tribe or Native Hawaiian organization and an identifiable earlier group.

(3) "cultural items" means human remains and-

(A) "associated funerary objects" which shall mean objects that, as a part of the death rite or ceremony of a culture, are reasonably believed to have been placed with individual human remains either at the time of death or later, and both the human remains and associated funerary objects are presently in the possession or control of a Federal agency or museum, except that other items exclusively made for burial purposes or to contain human remains shall be considered as associated funerary objects.

(B) "unassociated funerary objects" which shall mean objects that, as a part of the death rite or ceremony of a culture, are reasonably believed to have been placed with individual human remains either at the time of death or later, where the remains are not in the possession or control of the Federal agency or museum and the objects can be identified by a preponderance of the evidence as related to specific individuals or families or to known human remains or, by a preponderance of the evidence, as having been removed from a specific burial site of an individual culturally affiliated with a particular Indian tribe,

(C) "sacred objects" which shall mean specific ceremonial objects which are needed by traditional Native American religious leaders for the practice of traditional Native American religions by their present day adherents, and

(D) "cultural patrimony" which shall mean an object having ongoing historical, traditional, or cultural importance central to the Native American group or culture itself, rather than property owned by an individual Native

American, and which, therefore, cannot be alienated, appropriated, or conveyed by any individual regardless of whether or not the individual is a member of the Indian tribe or Native Hawaiian organization and such object shall have been considered inalienable by such Native American group at the time the object was

separated from such group.

(4) "Federal agency" means any department, agency, or instrumentality of the United States. Such term does not include the Smithsonian Institution.

(5) "Federal lands" means any land other than tribal lands which are controlled or owned by the United States, including lands selected by but not yet conveyed to Alaska Native Corporations and groups organized pursuant to the Alaska Native Claims Settlement Act of 1971.

(6) "Hui Malama I Na Kupuna O Hawai'i Nei" means the nonprofit, Native Hawaiian organization incorporated under the laws of the State of Hawaii by that name on April 17, 1989, for the purpose of providing guidance and expertise in decisions dealing with Native Hawaiian cultural issues, particularly burial issues.

(7) "Indian tribe" means any tribe, band, nation, or other organized group or community of Indians, including any Alaska Native village (as defined in, or established pursuant to, the Alaska Native Claims Settlement Act), which is recognized as eligible for the special programs and services provided by the United States to Indians because of their status as Indians.

(8) "museum" means any institution or State or local government agency (including any institution of higher learning) that receives Federal funds and has possession of, or control over, Native American cultural items. Such term does not include the Smithsonian Institution or any other Federal agency.

(9) "Native American" means of, or relating to, a tribe, people, or culture that is indigenous to the United States.

(10) "Native Hawaiian" means any individual who is a descendant of the aboriginal people who, prior to 1778, occupied and exercised sovereignty in the area that now constitutes the State of Hawaii.

(11) "Native Hawaiian organization" means any organization which--

(A) serves and represents the interests of Native Hawaiians,

(B) has as a primary and stated purpose the provision of services to Native Hawaiians, and

(C) has expertise in Native Hawaiian Affairs, and shall include the Office of Hawaiian Affairs and Hui Malama I Na Kupuna O Hawai'i Nei.

(12) "Office of Hawaiian Affairs" means the Office of Hawaiian Affairs established by the constitution of the State of Hawaii.

(13) "right of possession" means possession obtained with the voluntary consent of an individual or group that had authority of alienation. The original acquisition of a Native American unassociated funerary object, sacred object or object of cultural patrimony from an Indian tribe or Native Hawaiian organization with the voluntary consent of an individual or group with authority to alienate such object is deemed to give right of possession of that object, unless the phrase so defined would, as

applied in section 7(c), result in a Fifth Amendment taking by the United States as determined by the United States Claims Court pursuant to 28 U.S.C. 1491 in which event the "right of possession" shall be as provided

under otherwise applicable property law. The original acquisition of Native American human remains and associated funerary objects which were excavated, exhumed, or otherwise obtained with full knowledge and consent of the next of kin or the official governing body of the appropriate culturally affiliated Indian tribe or Native Hawaiian organization is deemed to give right of possession to those remains.

(14) "Secretary" means the Secretary of the Interior.

(15) "tribal land" means-

(A) all lands within the exterior boundaries of any Indian reservation;

(B) all dependent Indian communities;

(C) any lands administered for the benefit of Native Hawaiians pursuant to the Hawaiian Homes Commission Act, 1920, and section 4 of Public Law 86-3.

25 USC 3002. SEC 3. OWNERSHIP.

(a) NATIVE AMERICAN HUMAN REMAINS AND OBJECTS.--The ownership or control of Native American cultural items which are excavated or discovered on Federal or tribal lands after the date of enactment of this Act shall be (with priority given in the order listed)--

(1) in the case of Native American human remains and associated funerary objects, in the lineal descendants of the Native American; or

(2) in any case in which such lineal descendants cannot be ascertained, and in the case of unassociated funerary objects, sacred objects, and objects of cultural patrimony--

(A) in the Indian tribe or Native Hawaiian organization on whose tribal land such objects or remains were discovered;

Claims. (B) in the Indian tribe or Native Hawaiian organization which has the closest cultural affiliation with such remains or objects and which, upon notice, states a claim for such remains or objects; or

(C) if the cultural affiliation of the objects cannot be reasonably ascertained and if the objects were discovered on Federal land that is recognized by a final judgment of the Indian Claims Commission or the United States Court of Claims as the aboriginal land of some Indian tribe--

(1) in the Indian tribe that is recognized as aboriginally occupying the area in which the objects were discovered, if upon notice, such tribe states a claim for such remains or objects, or

(2) if it can be shown by a preponderance of the evidence that a different tribe has a stronger cultural relationship with the remains or objects than the tribe or organization specified in paragraph (1), in the Indian tribe that has the strongest demonstrated relationship, if upon notice, such tribe states a claim for such remains or objects.

Regulations. (b) UNCLAIMED NATIVE AMERICAN HUMAN REMAINS AND OBJECTS.--Native American cultural items not claimed under subsec-

tion (a) shall be disposed of in accordance., with regulations promulgated by the Secretary- in consultation

with the review committee established under section 8,-Native American groups, representatives of museums and the scientific community.

(C) INTENTIONAL EXCAVATION AND REMOVAL OF NATIVE AMERICAN HUMAN REMAINS AND OBJECTS.--The intentional removal from or excavation of Native American cultural items from Federal or tribal lands for purposes of discovery, study, or removal of such items is permitted only if--

(1) such items are excavated or removed pursuant to a permit issued under section 4 of the Archaeological Resources Protection Act of 1979 (93 Stat. 721; 16 U.S.C. 470aa et seq.) which shall be consistent with this Act;

(2) such items are excavated or removed after consultation with or, in the case of tribal lands, consent of the appropriate (if any) Indian tribe or Native Hawaiian organization;

(3) the ownership and right of control of the disposition of such items shall be as provided in subsections (a) and (b); and

(4) proof of consultation or consent under paragraph (2) is shown.

(d) INADVERTENT DISCOVERY OF NATIVE AMERICAN REMAINS AND OBJECTS.--(1) Any person who knows, or has reason to know, that such person has discovered Native American cultural items on Federal or tribal lands-after the date of enactment of this Act shall notify, in writing, the Secretary of the Department, or head of any other agency or instrumentality of the United States, having primary management authority with respect to Federal lands and the appropriate Indian tribe or Native Hawaiian organization with respect to tribal lands, if known or readily ascertainable, and, in the case of lands that have been selected by an Alaska Native Corporation or group organized pursuant to the Alaska Native Claims Settlement Act of 1971, the appropriate corporation or group. If the discovery occurred in connection with an activity, including (but not limited to) construction, mining, logging, and agriculture, the person shall cease the activity in the area of the discovery, make a reasonable effort to protect the items discovered before resuming such activity, and provide notice under this subsection. Following the notification under this subsection, and upon certification by the Secretary of the department or the head of any agency or instrumentality of the United States or the appropriate Indian tribe or Native Hawaiian organization that notification has been received, the activity may resume after 30 days of such certification.

(2) The disposition of and control over any cultural items excavated or removed under this subsection shall be determined as provided for in this section.

(3) If the Secretary of the Interior consents, the responsibilities (in whole or in part) under paragraphs (1) and (2) of the Secretary of any department (other than the Department of the Interior) or the head of any other agency or instrumentality may be delegated to the Secretary with respect to any land managed by such other Secretary or agency head.

(e) RELINQUISHMENT.--Nothing in this section shall prevent the governing body of an Indian tribe or Native Hawaiian organization from expressly relinquishing control over any Native American human remains, or title to or

control over any funerary object, or sacred object.

SEC. 4. ILLEGAL TRAFFICKING.

(a) ILLEGAL TRAFFICKING.--Chapter 53 of title 18, United States Code, is amended by adding at the end thereof the following new section:

" 1170. Illegal Trafficking in Native American Human Remains and Cultural Items

"(a) Whoever knowingly sells, purchases, uses for profit, or transports for sale or profit, the human remains of a Native American without the right of possession to those remains as provided in the Native American Graves Protection and Repatriation Act shall be fined in accordance with this title, or imprisoned not more than 12 months, or both, and in the case of a second or subsequent violation, be fined in accordance with this title, or imprisoned not more than 5 years, or both.

"(b) Whoever knowingly sells, purchases, uses for profit, or transports for sale or profit any Native American cultural items obtained in violation of the Native American Grave Protection and Repatriation Act shall be fined in accordance with this title, imprisoned not more than one year, or both, and in the case of a second or subsequent violation, be fined in accordance with this title, imprisoned not more than 5 years, or both.".

(b) TABLE OF CONTENTS.--The table of contents for chapter 53 of title 18, United States Code, is amended by adding at the end thereof the following new item:

"1170. Illegal Trafficking in Native American Human Remains and Cultural Items.".

Museums.
25 USC 3003.

SEC. 5. INVENTORY FOR HUMAN REMAINS AND ASSOCIATED FUNERARY OBJECTS.

(a) IN GENERAL.--Each Federal agency and each museum which has possession or control over holdings or collections of Native American human remains and associated funerary objects shall compile an inventory of such items and, to the extent possible based on information possessed by such museum or Federal agency, identify the geographical and cultural affiliation of such item.

(b) REQUIREMENTS.--(1) The inventories and identifications required under subsection (a) shall be--

(A) completed in consultation with tribal government and Native Hawaiian organization officials and traditional religious leaders;

(B) completed by not later than the date that is 5 years after the date of enactment of this Act, and

(C) made available both during the time they are being conducted and afterward to a review committee established under section 8.

(2) Upon request by an Indian tribe or Native Hawaiian organization which receives or should have received notice, a museum or Federal agency shall supply additional available documentation to supplement the information required by subsection (a) of this section. The term "documentation" means a summary of existing museum or

Federal agency records, including inventories or catalogues, relevant studies, or other pertinent data for the limited purpose of determining the geographical origin, cultural affiliation, and basic facts surrounding acquisition and accession of Native American human remains and associated funerary objects subject to this section. Such term does not mean, and this Act shall not be

construed to be an authorization for, the initiation of new scientific studies of such remains and associated funerary objects or other means of acquiring or preserving additional scientific information from such remains and objects.

(c) EXTENSION OF TIME FOR INVENTORY.--Any museum which has made a good faith effort to carry out an inventory and identification under this section, but which has been unable to complete the process, may appeal to the Secretary for an extension of the time requirements set forth in subsection (b)(1)(B). The Secretary may extend such time requirements for any such museum upon a finding of good faith effort. An indication of good faith shall include the development of a plan to carry out the inventory and identification process.

(d) NOTIFICATION--(1) If the cultural affiliation of any particular Native American human remains or associated funerary objects is determined pursuant to this section, the Federal agency or museum concerned shall, not later than 6 months after the completion of the inventory, notify the affected Indian tribes or Native Hawaiian organizations.

(2) The notice required by paragraph (1) shall include information--

(A) which identifies each Native American human remains or associated funerary objects and the circumstances surrounding its acquisition;

(B) which lists the human remains or associated funerary objects that are clearly identifiable as to tribal origin; and

(C) which lists the Native American human remains and associated funerary objects that are not clearly identifiable as being culturally affiliated with that Indian tribe or Native Hawaiian organization, but which, given the totality of circumstances surrounding acquisition of the remains or objects, are determined by a reasonable belief to be remains or objects culturally affiliated with the Indian tribe or Native Hawaiian organization.

(3) A copy of each notice provided under paragraph (1) shall be sent to the Secretary who shall publish each notice in the Federal Register. Federal Register, publication.

(e) INVENTORY.--For the purposes of this section, the term "inventory" means a simple itemized list that summarizes the information called for by this section.

SEC. 6. SUMMARY FOR UNASSOCIATED FUNERARY OBJECTS, SACRED OBJECTS, AND CULTURAL PATRIMONY. 25 USC 3004.

(a) IN GENERAL.--Each Federal agency or museum which has possession or control over holdings or collections of Native American unassociated funerary objects, sacred objects, or objects of cultural patrimony shall provide a written summary of such objects based upon available Museums.

information held by such agency or museum. The summary shall describe the scope of the collection, kinds of objects included, reference to geographical location, means and period of acquisition and cultural affiliation, where readily ascertainable.

(b) REQUIREMENTS.-- (1) The summary required under subsection (a) shall be--

(A) in lieu of an object-by-object inventory;

(B) followed by consultation with tribal government and Native Hawaiian organization officials and traditional religious leaders; and

(C) completed by not later than the date that is 3 years after the date of enactment of this Act.

(2) Upon request, Indian Tribes and Native Hawaiian organizations shall have access to records, catalogues, relevant studies or other pertinent data for the limited purposes of determining the geographic origin, cultural affiliation, and basic facts surrounding acquisition and accession of Native American objects subject to this section. Such information shall be provided in a reasonable manner to be agreed upon by all parties.

25 USC 3005. SEC. 7. REPATRIATION.

(a) REPATRIATION OF NATIVE AMERICAN HUMAN REMAINS AND OBJECTS POSSESSED OR CONTROLLED BY FEDERAL AGENCIES AND MUSEUMS.--(1) If, pursuant to section 5, the cultural affiliation of Native American human remains and associated funerary objects with a particular Indian tribe or Native Hawaiian organization is established, then the Federal agency or museum, upon the request of a known lineal descendant of the Native American or of the tribe or organization and pursuant to subsections (b) and (e) of this section, shall expeditiously return such remains and associated funerary objects.

(2) If, pursuant to section 6, the cultural affiliation with a particular Indian tribe or Native Hawaiian organization is shown with respect to unassociated funerary objects, sacred objects or objects of cultural patrimony, then the Federal agency or museum, upon the request of the Indian tribe or Native Hawaiian organization and pursuant to subsections (b), (c) and (e) of this section, shall expeditiously return such objects.

(3) The return of cultural items covered by this Act shall be in consultation with the requesting lineal descendant or tribe or organization to determine the place and manner of delivery of such items.

(4) Where cultural affiliation of Native American human remains and funerary objects has not been established in an inventory prepared pursuant to section 5, or the summary pursuant to section 6, or where Native American human remains and funerary objects are not included upon any such inventory, then, upon request and pursuant to subsections (b) and (e) and, in the case of unassociated funerary objects, subsection (c), such Native American human remains and funerary objects shall be expeditiously returned where the requesting Indian tribe or Native Hawaiian organization can show cultural affiliation by a preponderance of the evidence based upon geographical, kinship, biological, archaeological, anthropological, linguistic, folkloric, oral traditional, historical, or

other relevant information or expert opinion.

(5) Upon request and pursuant to subsections (b), (c) and (e), sacred objects and objects of cultural patrimony shall be expeditiously returned where--

(A) the requesting party is the direct lineal descendant of an individual who owned the sacred object;

(B) the requesting Indian tribe or Native Hawaiian organization can show that the object was owned or controlled by the tribe or organization; or

(C) the requesting Indian tribe or Native Hawaiian organization can show that the sacred object was owned or controlled by a member thereof, provided that in the case where a sacred object was owned by a member thereof, there are no identifiable

lineal descendants of said member or the lineal descendent, upon notice, have failed to make a claim for the object under this Act.

(b) SCIENTIFIC STUDY.--If the lineal descendant, Indian tribe, or Native Hawaiian organization requests the return of culturally affiliated Native American cultural items, the Federal agency or museum shall expeditiously return such items unless such items are indispensable for completion of a specific scientific study, the outcome of which would be of major benefit to the United States. Such items shall be returned by no later than 90 days after the date on which the scientific study is completed.

(c) STANDARD OF REPATRIATION.--If a known lineal descendant or an Indian tribe or Native Hawaiian organization requests the return of Native American unassociated funerary objects, sacred objects or objects of cultural patrimony pursuant to this Act and presents evidence which, if standing alone before the introduction of evidence to the contrary, would support a finding that the Federal agency or museum did not have the right of possession, then such agency or museum shall return such objects unless it can overcome such inference and prove that it has a right of possession to the objects.

(d) SHARING OF INFORMATION BY FEDERAL AGENCIES AND MUSEUMS.--Any Federal agency or museum shall share what information it does possess regarding the object in question with the known lineal descendant, Indian tribe, or Native Hawaiian organization to assist in making a claim under this section.

(e) COMPETING CLAIMS.--Where there are multiple requests for repatriation of any cultural item and, after complying with the requirements of this Act, the Federal agency or museum cannot clearly determine which requesting party is the most appropriate claimant, the agency or museum may retain such item until the requesting parties agree upon its disposition or the dispute is otherwise resolved pursuant to the provisions of this Act or by a court of competent jurisdiction.

(f) MUSEUM OBLIGATION.--Any museum which repatriates any item in good faith pursuant to this Act shall not be liable for claims by an aggrieved party or for claims of breach of fiduciary duty, public trust, or violations of state law that are inconsistent with the provisions of this Act.

SEC. 8. REVIEW COMMITTEE. 25 USC 3006.

(a) ESTABLISHMENT.--Within 120 days after the date of enactment of this Act, the Secretary shall establish a committee to monitor and review the implementation of the inventory and identification process and repatriation activities required under sections 5, 6 and 7.

(b) MEMBERSHIP--(1) The Committee established under subsection (a) shall be composed of 7 members,

(A) 3 of whom shall be appointed by the Secretary from nominations submitted by Indian tribes, Native Hawaiian organizations, and traditional Native American religious leaders with at least 2 of such persons being traditional Indian religious leaders;

(B) 3 of whom shall be appointed by the Secretary from nominations submitted by national museum organizations and scientific organizations; and

(C) 1 who shall be appointed by the Secretary from a list of persons developed and consented to by all of the members appointed pursuant to subparagraphs (A) and (B).

(2) The Secretary may not appoint Federal officers or employees to the committee.

(3) In the event vacancies shall occur, such vacancies shall be filled by the Secretary in the same manner as the original appointment within 90 days of the occurrence of such vacancy.

(4) Members of the committee established under subsection (a) shall serve without pay, but shall be reimbursed at a rate equal to the daily rate for GS-18 of the General Schedule for each day (including travel time) for which the member is actually engaged in committee business. Each member shall receive travel expenses, including per diem in lieu of subsistence, in accordance with sections 5702 and 5703 of title 5, United States Code.

(c) RESPONSIBILITIES.--The committee established under subsection a) shall be responsible for-

(1) designating one of the members of the committee as chairman;

(2) monitoring the inventory and identification process conducted under sections 5 and 6 to ensure a fair, objective consideration and assessment of all available relevant information and evidence;

(3) upon the request of any affected party, reviewing and making findings related to-

(A) the identity or cultural affiliation of cultural items, or

(B) the return of such items;

(4) facilitating the resolution of any disputes among Indian tribes, Native Hawaiian organizations, or lineal descendants and Federal agencies or museums relating to the return of such items including convening the parties to the dispute if deemed desirable;

(5) compiling an inventory of culturally unidentifiable human remains that are in the possession or control of each Federal agency and museum and recommending specific actions for developing a process for disposition of such remains;

(6) consulting with Indian tribes and Native Hawaiian organizations and museums on matters within the scope of the work of the committee affecting such tribes or

organizations;

(7) consulting with the Secretary in the development of regulations to carry out this Act;

(8) performing such other related functions as the Secretary -may assign to the committee; and

(9) making recommendations, if appropriate, regarding future care of cultural items which are to be repatriated.

(d) Any records and findings made by the review committee pursuant to this Act relating to the identity or cultural affiliation of any cultural items and the return of such items may be admissible in any action brought under section 15 of this Act.

(e) RECOMMENDATIONS AND REPORT.--The committee shall make the recommendations under paragraph (c)(5) in consultation with Indian tribes and Native Hawaiian organizations and appropriate scientific and museum groups.

(f) ACCESS.--The Secretary shall ensure that the committee established under subsection (a) and the members of the committee have reasonable access to Native American cultural items under review and to associated scientific and historical documents.

Regulations. (g) DUTIES OF SECRETARY.--The Secretary shall--

(1) establish such rules and regulations for the committee as may be necessary, and

(2) provide reasonable administrative and staff support necessary for the deliberations of the committee.

(h) ANNUAL REPORT.--The committee established under subsection (a) shall submit an annual report to the Congress on the progress made, and any barriers encountered, in implementing this section during the previous year.

(i) TERMINATION.--The committee established under subsection (a) shall terminate at the end of the 120-day period beginning on the day the Secretary certifies, in a report submitted to Congress, that the work of the committee has been completed.

SEC. 9. PENALTY. Museums.

(a) PENALTY.--Any museum that fails to comply with the 25 USC 3007. requirements of this Act may be assessed a civil penalty by the Secretary of the Interior pursuant to procedures established by the Secretary through regulation. A penalty assessed under this subsection shall be determined on the record after opportunity for an agency hearing. Each violation under this subsection shall be a separate offense.

(b) AMOUNT OF PENALTY.--The amount of a penalty assessed under subsection (a) shall be determined under regulations promulgated pursuant to this Act, taking into account, in addition to other factors--

(1) the archaeological, historical, or commercial value of the item involved;

(2) the damages suffered, both economic and noneconomic, by an aggrieved party, and

(3) the number of violations that have occurred.

(c) ACTIONS TO RECOVER PENALTIES.--If any museum fails to pay courts. an assessment of a civil penalty pursuant Courts. to a final order of the Secretary that has been issued

under subsection (a) and not appealed or after a final judgment has been rendered on appeal of such order, the Attorney General may institute a civil action in an appropriate district court of the United States to collect the penalty. In such action, the validity and amount of such penalty shall not be subject to review.

(d) SUBPOENAS.--In hearings held pursuant to subsection (a), subpoenas may be issued for the attendance and testimony of witnesses and the production of relevant papers, books, and documents. Witnesses so summoned shall be paid the same fees and mileage that are paid to witnesses in the courts of the United States.

SEC. 10. GRANTS. 25 USC 3008.

(a) INDIAN TRIBES AND NATIVE HAWAIIAN ORGANIZATIONS.--The Secretary is authorized to make grants to Indian tribes and Native Hawaiian organizations for the purpose of assisting such tribes and organizations in the repatriation of Native American cultural items.

(b) MUSEUMS.--The Secretary is authorized to make grants to museums for the purpose of assisting the museums in conducting the inventories and identification required under sections 5 and 6.

SEC. 11. SAVINGS PROVISIONS. 25 USC 3009.

Nothing in this Act shall be construed to--

(1) limit the authority of any Federal agency or museum to--

(A) return or repatriate Native American cultural items to Indian tribes, Native Hawaiian organizations, or individuals, and

(B) enter into any other agreement with the consent of the culturally affiliated tribe or organization as to the disposition of, or control over, items covered by this Act;

(2) delay actions on repatriation requests that are pending on the date of enactment of this Act;

(3) deny or otherwise affect access to any court;

(4) limit any procedural or substantive right which may otherwise be secured to individuals or Indian tribes or Native Hawaiian organizations; or

(5) limit the application of any State or Federal law pertaining to theft or stolen property.

25 USC 3010. SEC. 12. SPECIAL RELATIONSHIP BETWEEN FEDERAL GOVERNMENT AND INDIAN TRIBES.

This Act reflects the unique relationship between the Federal Government and Indian tribes and Native Hawaiian organizations and should not be construed to establish a precedent with respect to any other individual, organization or foreign government.

25 USC 3011. SEC. 13. REGULATIONS.

The Secretary shall promulgate regulations to carry out this Act within 12 months of enactment.

25 USC 3012. SEC. 14. AUTHORIZATION OF APPROPRIATIONS.

There is authorized to be appropriated such sums as may be

necessary to carry out this Act.

25 USC 3013. SEC. 15. ENFORCEMENT.

The United States district courts shall have jurisdiction over any action brought by any person alleging a violation
Courts. of this Act and shall have the authority to issue such orders as may be necessary to enforce the provisions of this Act.

Approved November 16,1990.

LEGISLATIVE HISTORY--H.R. 5237:

HOUSE REPORTS: No. 101-877 (Comm. on Interior and Insular Affairs).

CONGRESSIONAL RECORD, Vol. 136 (1990):

Oct. 22, considered and passed House.

Oct. 25, considered and passed Senate; passage vitiated.

Oct. 26. reconsidered and passed Senate, amended.

Oct. 27, House concurred in Senate amendment.

Appendix 2

Part 1. Equipment needed and developmental process.

What follows is a brief list of: 1.) equipment needed to record holograms, 2.) materials needed for a darkroom, 3.) chemicals needed to develop a hologram and 4.) how to develop a hologram.

EQUIPMENT NEEDED TO RECORD HOLOGRAMS

1. laser
2. beam splitter
3. mirrors (varies according to type of hologram to be recorded)
4. plate or film holder
5. spacial filter (2) ----- (Cleans up the laser beam light by causing it to focus through a tiny aperture. Only pure light can focus at the desired point, eliminating the effects of dust and optical surface scratches.)
6. optical lens
7. gallon jugs to hold chemicals (3)
8. film or glass plate
9. polarize shifter ----- optional (It restricts light to vibration in only one plane.)
10. pinhole ----- (A small hole used to pass focused light from the objective in a spacial filter/it cleans up the laser light.)
11. green safelight

MATERIALS NEEDED FOR DARKROOM

1. green safelight
2. rubber tongs (2)

3. trays for chemicals (3)
4. squeegee (1)
5. rubber gloves
6. paper towels
7. timer
8. funnel ----- optional
9. measuring beaker
10. empty light proof box to transport exposed film to darkroom
11. small air dryer (i.e. hair dryer)

CHEMICALS NEEDED TO DEVELOP HOLOGRAM

1. EDTA (bleach)
2. Dichro (bleach) ---- sometimes heated to 100°
3. Pyro A (developer) ---- sometimes heated to 100° A{phenidone - 10G --- .6G
4. Pyro B (developer) B{sodium carbonate - 65G, sodium sulfate and hydro quinone
5. D-19 (developer)

DEVELOPING THE HOLOGRAM

1. After recorded the hologram is placed in a light proof box before the lights can be turned on. The hologram is then taken to the darkroom.
2. The exposed hologram is immersed in 70° - 80° water for three minutes (approximate time)
3. Then immersed in developer for four minutes (time can vary according to the type of hologram and chemicals used)

4. Then re-immersed in 70° - 80° water for approximately three minutes (stop bath)
5. Then it is immersed in stabilizer for approximately four minutes (time can vary according to the type of hologram and chemicals used)
6. It is then re-immersed in the 70° - 80° water again for three minutes (stop bath)
7. The holograms is then squeegeed off and dried (can use a hair dryer)
8. The hologram is then reconstructed according to the type made in order to check on clarity of it

PART 2. Cost of a lab.

The cost for a smaller lab that could have a 5 milowatt helium neon laser at a cost of $500 to $800 with a simple vibration isolation sandbox to control movement which could be built for roughly $40. Along with this optical devices are needed. Optics such as two regular lenses, two mirrors (4"x5"), plastic tubing for mounting the optics, a green safe light, chemicals for processing the holograms and film or glass plates. These specific pieces of equipment would cost approximately $300.

For the more versatile lab these costs would dramatically rise. This would entail a 50 milowatt helium neon laser at a cost of $60,000, a 4'x10' well-designed vibration free floating table. This table floats on legs that use compressed air. The table and legs cost $40,000 and the compressor cost is $750 to $800. Optics can range up to $10,000. Such optics as one spacial filter can cost $600. Magnetic bases without mirrors attached can cost $100 to $200 each (Tyler, personal interview).

PART 3. Technique of producing an integral hologram.

What is needed first is to make an optic selection and an evaluation process. A

regular VHS cam-recorder or a digital camera is used to record or make the recordings of the object to be used in the hologram and to evaluate the recordings. For the video digitizing part a Macintosh 2ci is needed that has a special board called a Rosteropt 364 or for the digital camera a Macintosh and adobe photoshop software which is also used for image analysis. Doing the image processing of the 80 frames uses the program DeBakelizer for pallet correction and image processing.

In the holography lab the Macintosh 2ci is used again to project the images through a view frame spectra c liquid crystal projection panel or viewer. Each digitized frame is projected through the system onto ground glass and recorded holographicly. The mastering process consists of recording each frame consecutively in line next to each other. This is actually thin slits (slit moves across the film) stacked next to each other resulting in a transmission master. Holographic transform H2, the developing of the film takes place in the same process as other holograms. This master hologram plate is then used to make the rainbow holographic renderings of the original artifact which can be played back or viewed with the aid of white light.

Appendix 3

Attached after the works cited pages are two reflection holograms; the first one is a lithic point and the second one is a pottery shard.

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